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THE 9 DE JULIO.

THIS vessel, which has been constructed by Sir W. G. Armstrong, Mitchell & Co. for the Argentine Navy, has recently undergone her gun and steam trials with marked success, the latter trial having conclusively shown that she is the fastest cruiser afloat and possesses a speed which, under natural draught, has only been equaled by the fastest of the Atlantic liners in the most favorable conditions of wind and sea.

She is similar in type to, but larger than, the 25 de Mayo, which was also constructed by Sir W. G. Armstrong, Mitchell & Co., for the Argentine Navy. She is 350 ft. long, 44 ft. broad, and has a displacement of 3,500 tons.

The vessel is armed entirely with quick-firing guns of the latest and most approved pattern, made by the Elswick firm. She carries four 6 in. quick-firing guns, eight 4·7 in. quick-firing guns, twelve 3 pr. quick-firing guns and twelve 1 pr. quick-firing guns. She also carries five 18 in. torpedo tubes. One of the 6 in. guns is mounted in the middle line on the forecastle and one in the middle line on the poop, each having a considerable arc of training around the bow and stern respectively. The other two 6 in. guns are mounted in sponsons forward on the upper deck, so as to enable them to be fired from direct ahead to 50° abaft the beam. The 4·7 in. guns are mounted also in sponsons at the sides of the upper deck; the aftermost pair of these can fire from direct astern to 50° before the beam, while the others have arcs of training of 120° on the broadside.

A steel protective deck of the customary form with this type of vessel protects the vitals of the ship, the machinery, magazines, etc., from the effects of gun fire; and the protection it affords is assisted by coal carried on this deck in bunkers at the side of the ship. This steel deck has a maximum thickness of $4\frac{1}{2}$ in. on its sloping sides, and an uniform thickness of $1\frac{3}{4}$ in. on all its horizontal portions.

The propelling machinery, constructed by Messrs. Humphrys, Tennant & Co., London, consists of two sets of four cylinder triple-expansion engines, the two low pressure cylinders in each set having a diameter of 66 in., the intermediate cylinder a diameter of 60 in., and the high pressure cylinder a diameter of 40 in., the length of the stroke being 30 in. Steam is generated in eight single-ended return-tube boilers, situated in two separate water-tight compartments, each compartment containing four boilers. Each set of engines is also confined in a water-tight compartment.

The bunkers of the vessel are capable of holding 770 tons of coal, which would enable her to steam a distance of about 10,000 knots at her most economical speed.

On January 25, a series of progressive runs were made with the vessel on the Hartley measured mile, north of the mouth of the river Tyne. The speeds ranged from $11\frac{3}{4}$ knots up to 22·74 knots, the latter mean speed being obtained under forced draught with an air pressure of about 1 7-10 in. of water.

The forced draught runs took place at the end of the day when the light was failing, and the ship consequently had to be run nearer the land in order that the mile posts could be seen with certainty. The depth of water in which the ship was running during these forced draught runs was from ten to eleven fathoms, which was insufficient to allow of a proper and satisfactory performance at such a high speed. Had the ship been tried in a depth of water of eighteen to twenty fathoms, which can easily be done on this part of the coast on a clear day, there can be little doubt that she would have exceeded a speed of 23 knots with the same expenditure of power as that realized during the trial, viz., 14,350 horses.

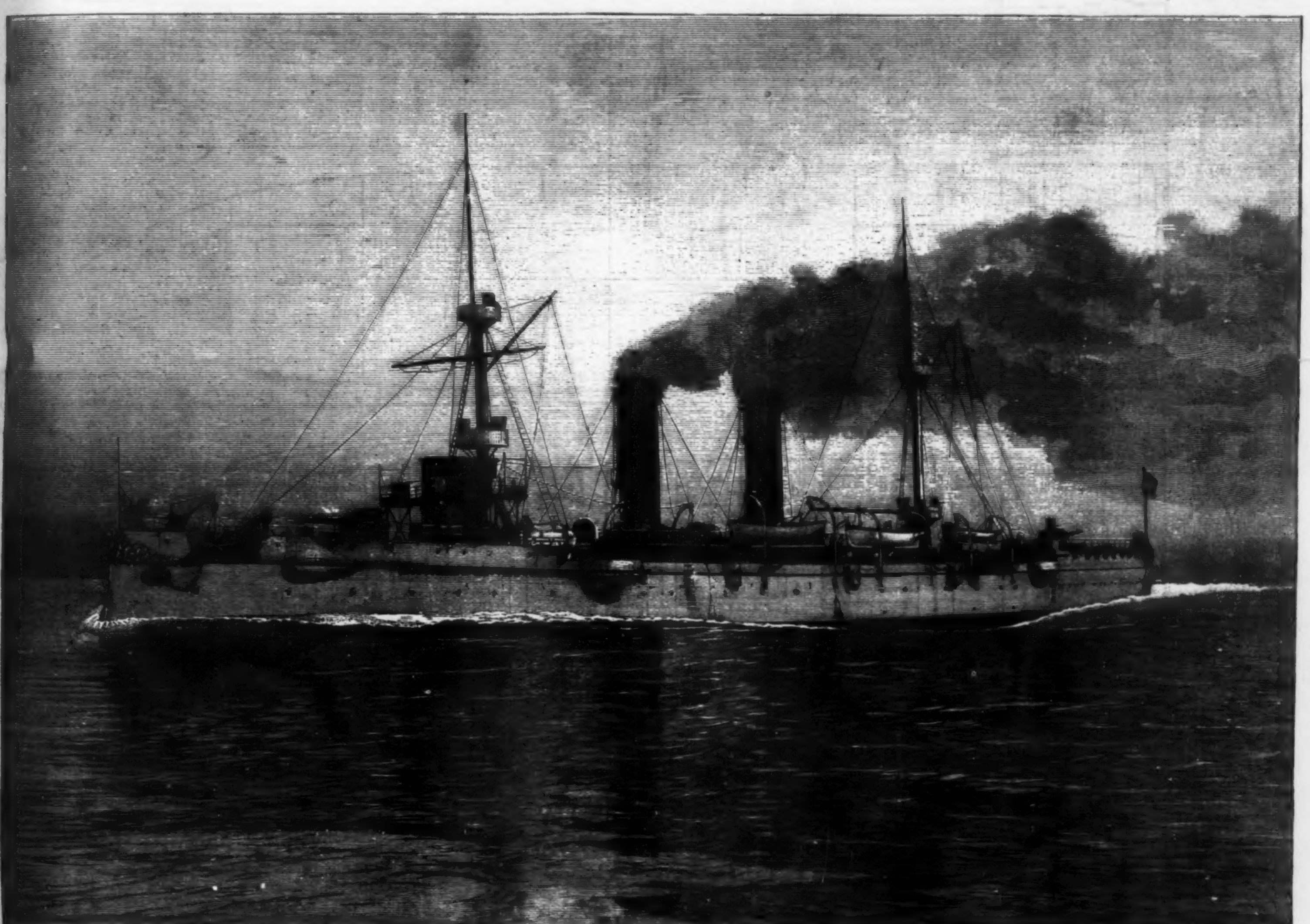
The machinery worked smoothly and without any hitch during this trial, as well as in the succeeding trial of six hours' duration on January 27, and there was an almost entire absence of vibration of ship at all speeds. When the engines were making about 120 revolutions per minute a very slight vibration could be felt; but it was very slight, and disappeared altogether when the engines were working at revolutions below and above this speed. At the highest speed the ship was perfectly steady.

The six hours' run was made under natural draught, in accordance with the conditions laid down by the British Admiralty, with results that must be gratifying to the designer of the vessel, Mr. P. Watts, of the Elswick firm, and also to the Argentine Commission. During the six hours the average speed of the vessel was as high as 21·943 knots, exceeding the speed of the 25 de Mayo in a similar trial by nearly three-quarters of a knot.

During the six hours' steaming four runs were taken on the measured mile, and the speeds and revolutions were accurately taken by stop watches and the mechanical counters in the engine rooms; the speeds and revolutions were also recorded by an electric apparatus in the charthouse of the ship, which noted on a traveling band of paper each revolution of each engine, each half second of time, and the beginning and ending of each run for the mile. The mean speed of these four runs was 22·028 knots, corresponding to the mean revolutions of engines of 149·1 per minute. The average revolutions of the engines during the six hours' run were 148·3 per minute.

Gunnery trials were also made on January 25, in order to test the working of the guns and the strength of the structure of the ship. During these trials three rounds were fired from each gun, one round with extreme training forward and horizontal, one round on the beam with extreme depression, and one round with extreme training aft and with extreme elevation. Broadsides were also fired from each side, and the 6 in. guns mounted in the center line on the forecastle and poop were fired horizontally in the line of the keel. Severe as this last trial was, no damage was done to the vessel. Guns and mountings worked perfectly, and not a hitch occurred to mar the success of the trials.

Our engraving is from an instantaneous photograph taken while the ship was running at full speed. It shows very clearly the peculiar form of the great wave of displacement which always accompanies the progress of ships of exceptionally high speeds.—*The Engineer, London.*



THE NEW ARGENTINE CRUISER 9 DE JULIO, THE FASTEST CRUISER AFLOAT—3,500 TONS, 14,350 H. P.

A LIGHT suspension bridge was built at Niagara Falls in 1848, and removed in 1854.

DOUBLE STERN WHEEL PASSENGER STEAMER.

We illustrate a stern wheel passenger steamer constructed by Messrs. Lobnitz & Co., Renfrew, the distinctive feature of which is that it is fitted with two stern wheels, as shown in Fig. 2, thus admitting of a central rudder—an arrangement which improves the steering qualities of the vessel. In ordinary stern wheel steamers, with one central paddle wheel, it is often considered necessary to fit two or three rudders, and even then they do not steer so well as the type illustrated.

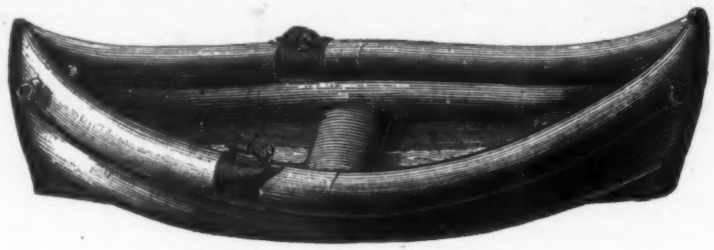
In the case of the steamer now under notice the wheels have feathering floats, as the speed to be attained was high—13 miles. The machinery, too, is of somewhat novel type for this class of vessel. Usually high pressure locomotive boilers are used, but, requiring special care, sometimes give trouble where unskilled native attendants have to be employed. Messrs. Lobnitz have therefore fitted the ordinary marine tubular boiler forward as usual (Fig. 2). This supplies steam to the compound surface condensing engines, placed aft, but in the center line of the ship.

As will be seen by the perspective view annexed, the engines have the cylinders placed tandemwise, and the pumps are arranged to compensate to a great extent for the unequal movement of a single crank tandem engine. The result in working is that the vessel works steadily, and the slight jerk usual with single crank paddle engines is hardly apparent. The cylinders are 20 in. and 36 in. in diameter respectively, with a stroke of 54 in.

The rudder acts pretty much as in an ordinary steamer, and as a result the boat can be steered in a most tortuous river with great ease. The vessel is 135 ft. long by 27 ft. beam by 6 ft. depth. The general arrangement of cabins, etc., will be readily appreciated by reference to Figs. 2 and 3. Messrs. Lobnitz have constructed several vessels of this type, and they have given satisfactory results. The stern wheelers usually tow special lighters which carry large quantities of cargo on a shallow draught.—*Engineering.*

A NEW LIFE BOAT.

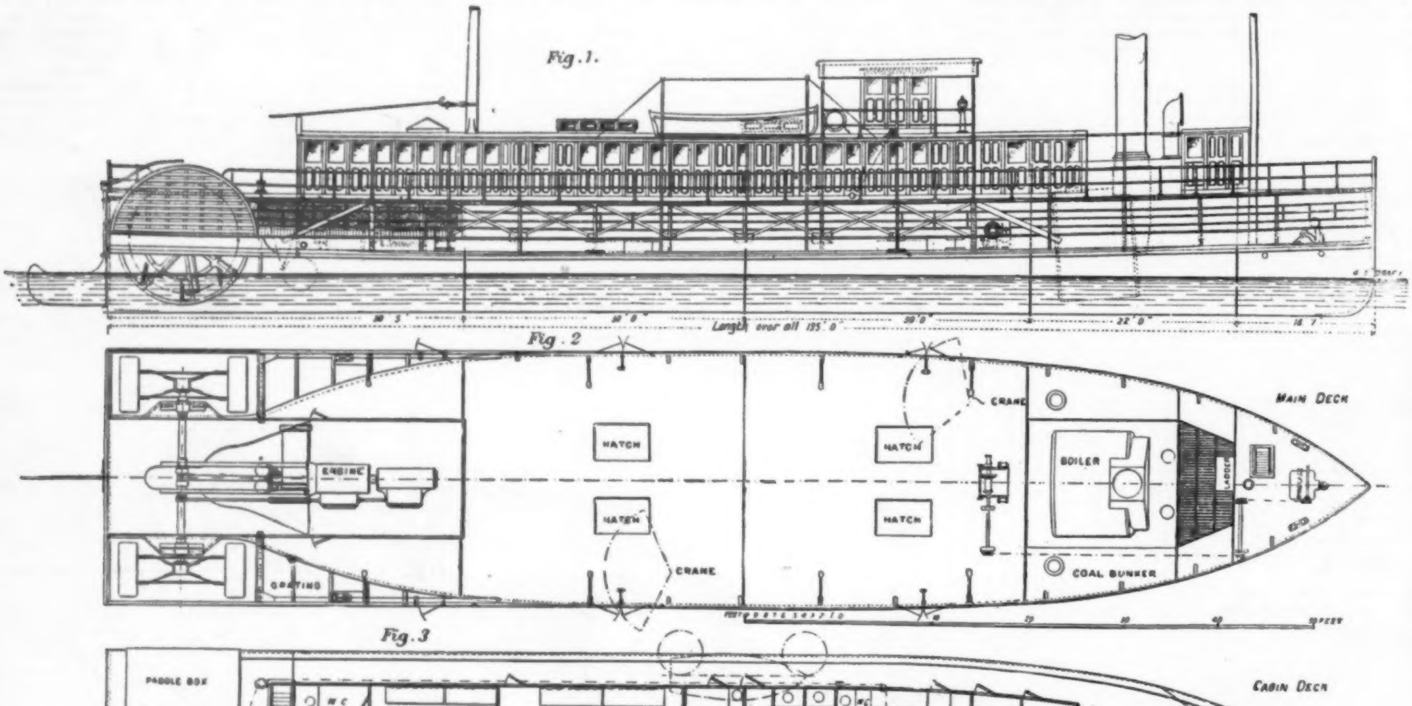
The "Walfisch" life boat combines the collapsibility of sailcloth boats with the air boxes of the iron and wooden life boats, the boxes being filled with reindeer hair, which has been successfully used in life preservers.

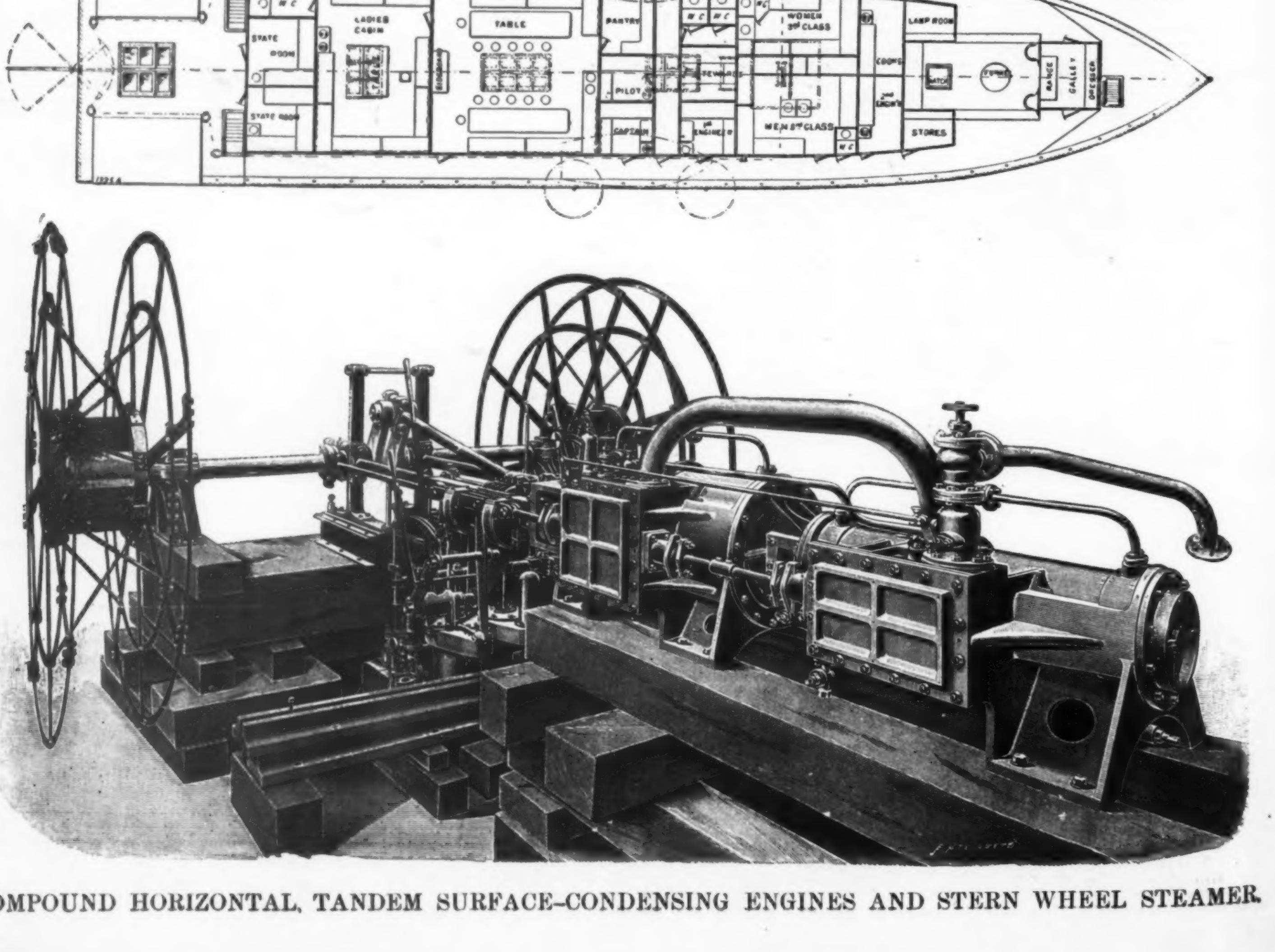


THE LIFE BOAT WALFISCH.

The sides of the boat consist of several pads or cushions made of sailcloth and stuffed with this hair. The flat bottom is made of double sailcloth. Other sailcloth cushions filled with reindeer hair form the seats, but these are stiffened by means of boards.

These seats, in nautical language "thwarts," are





COMPOUND HORIZONTAL, TANDEM SURFACE-CONDENSING ENGINES AND STERN WHEEL STEAMER.

pressed in the ridges between the pads forming the sides of the boat, thus giving it the necessary stiffness. Preferably, the boat is also stiffened longitudinally by a board or lath laid on the bottom. Later, it may be thought best to replace this by a wooden or iron keel. Leather loops are placed on the upper pads for holding the oars. Both ends of the boat are provided with iron rings, to which lines can be fastened or in which hoisting tackle can be hooked. When not in use, that is, when on shipboard or when being transported overland, the thwarts and the bottom board are taken out and the sides are folded together, so that the whole can be tied up in a comparatively small package. The smallest "Walfisch" boat is 8 ft. long, 2 ft. 3 in. wide, and 11 in. deep, and weighs about 34 lb. It will hold two men, but can be carried overland by one man.

It is well known that on war vessels the hammocks of the crew are kept tied up so tight that they look like sailcloth cushions. This is done, not simply as a matter of discipline, but because when in this condition they have sufficient buoyancy to sustain a man forty-eight hours above water. These hammocks owe their buoyancy to a hair mattress that is rolled up in each one. Norwegians have proved by long experience that reindeer hair is specially buoyant, and, therefore, it is thought that even if these boats ship water, or their bottoms are cut on rocks, or even if the sailcloth coverings of the cushions are injured, they will still keep afloat. If experiment proves this to be the case, they will have a great future. The test made on the Elbe November 23 showed them to have great buoyancy and stability in quiet waters. These boats were invented by Mr. Baswitz, a sailcloth manufacturer, of Berlin. PROMETHEUS.

ON POTTERY GLAZES—THEIR CLASSIFICATION AND DECORATIVE VALUE IN CERAMIC DESIGN.*

By WILTON P. RIX.

IN approaching the subject which I have ventured to bring before you, I am well aware that others have previously dealt—far more ably than I could hope to do—with many of the details which may now occupy our attention. Nevertheless, it seemed possible to add some points of interest to the valuable lectures already delivered before the Society (notably those of Professor Church, on "Pottery and Porcelain"), by entering somewhat more closely into the range of practical ceramics.

While attempting to draw some distinctions between various glazes, I propose to show how important a part is played by the composition and quality of these in enhancing the beauty of ceramic decoration; also touching briefly on some of the complex optical principles involved in the due appreciation of its merits.

In many cases glaze is to a pottery designer what the canvas is to a picture painter—the field whereon he is able to express his conceptions. But it is sometimes more than this; it is often the varnish which, while protecting his work, gives brilliancy to his coloring. Nor is this all; in many instances it is allowed to become the vehicle by means of which the design is harmonized, and mellowed into a beauty of tone, only possible to the painter on canvas after long years of patient waiting for time itself to effect.

Glaze may be translucent, transparent, or refractive; it may be iridescent or full of the richest coloring; and it may be soft as vellum or brilliant as the diamond in its texture; in short, it is capable of producing, under the touch of a master hand, a harmony of result, rich and powerful in tone as an autumn sunset or tender and delicate as the dawn of spring.

It is not necessary to occupy time by referring to the origin and development of glaze in pottery. The various stages, from the closing of the surface of a porous, sunbaked ware, with some cerate to make it water tight, onward to the brilliant texture of true porcelain, embrace the entire range from primitive utility to the highest decorative embellishment, fascinating to the eye and exquisite to the touch.

Though the functions of a glaze are mainly to render the ware impervious and cleanly, and to impart smoothness to the surface, it must be conceded that, in decorative pottery, these qualities are often made to subserve the embellishment of the object.

In the case of this Satsuma vase, for instance, the fine crackle adds greatly to the beauty of the result; but it undoubtedly holds the dirt and grease.

It is no part of our province, at present, to discuss how far such sacrifice of the useful to the æsthetic is legitimate. It will rather be attempted to show how the treatment of the glaze itself may serve to enhance the beauty of the material, by employing its peculiarities to the best advantage in the decoration of the ware.

DEFINITIONS.

Two main subdivisions are at once marked out by the method of the preparation, viz., raw and fritted glazes.

A glaze may have all the materials requisite to its composition carefully ground, and held in suspension by water or other vehicle, and when the needful heat is applied upon the surface of the ware, these materials are fused into a vitreous glaze or enamel—as shown in these specimens of fired and unfired enameled stoneware—such is termed a "raw" glaze.

It is possible to secure satisfactory fusion by this method when the materials are insoluble, but when soluble alkaline and other salts are added, it is necessary to melt, or flux, the ingredients together, thus insuring ultimate vitrification. After grinding the resulting "frit" in water, the ware is, as before, covered with this "fritted" glaze, as shown in this example of earthenware.

Moreover, the composition may be so arranged that the firing of the ware and of the glaze is accomplished at one operation, or, if necessary, the body may be fired before glazing.

For decorative purposes, these distinctions have a most important influence on the result, as will hereafter be seen.

The general term, glaze, may be broadly divided, according to texture, into five main divisions:

1, Enamels; 2, Glazes; 3, Smears; 4, Flows; 5, Salt or Vaprous Glazes; 6, Lusters.

* Journal Society of Arts, London. A recent lecture before the Society.

1. *Enamels* may be opaque or translucent. Covering the surface, they altogether conceal or partially modify the color of the ware beneath. This may be affected by various means:

(*a*) By fusion with metallic oxides, as tin or arsenic.
(*b*) By suspension of opaque particles in a transparent glaze.
(*c*) By semi-fusion of raw glaze.

Examples of each of these methods are here seen.

2. *Glazes.*—The term glaze is properly confined to a transparent varnish covering the ware. It may be:

(*a*) Colorless.
(*b*) Stained, or
(*c*) Curdled.

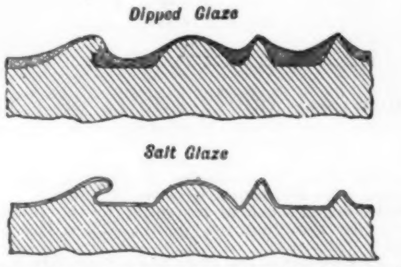
(Specimens of each are shown on the table.)

3. *Smear* is a thin, transparent semi-glaze sublimed on the ware during firing. The inner surface of the sagger in which the object is placed in the kiln is washed with a mixture of lead, alkali, or other material capable of volatilizing by high temperature. Small quantities of this mixture are sublimed upon the ware, giving the delicate texture seen here. When a clay contains much soluble alkaline salt, these by evaporation of moisture are brought to the surface, and during firing often produce a "smear" upon the ware.

4. *Flows* are somewhat distinct from "smears," although applied similarly. Volatile salts are mixed with carbonate of lime, etc., and placed within the sagger, causing a vapor which increases the fusion of the glaze already laid upon the ware, at the same time swimming the color, and thus imparting softness to the design as shown here.

5. *Salt Glaze.*—Altogether distinct from the above methods is that of salt glazing—made familiar to most by the interesting examples of old Gres de Flandres and Burslem stoneware, and in modern times by the well-known productions of Messrs. Doulton, at Lambeth. The process so often described is as simple in its operation as it is complex in its chemical reaction. The ware, when dry, is placed without glazing in the kiln. When at the vitrifying temperature common salt is added through small holes in the roof of the kiln. The consequent vapor fills the entire interior of the kiln, attacking every portion of the surface of the ware, and forms by chemical combination an extremely hard and thin glaze. One great advantage of this method is the equality of thickness afforded by the glaze to every part exposed. In a dipped glaze, on the contrary, the hollows are often unduly filled up to the detriment of the piece, as seen in this diagram.

FIG. 1.



SECTIONS SHOWING COMPARISON OF DIPPED AND SALT GLAZE.

6. *Lusters* are sometimes produced by the decomposition of a metallic glaze on its surface through the exposure to reducing atmosphere in the kiln. The best results are very difficult to attain.

CLASSIFICATION.

The classification of glazes has been attempted at different times with varying success. Brongniart gives three classes only.

1. Varnishes, or glazes fixed at a low heat, including those with lead and borax.
2. Enamels, or opaque glazes.
3. Cover, or glass earth, including those which mostly fire at high temperatures equal to that of the ware itself.

Salvetat divides into seven classes, thus:

1. Lead glaze—Coarse earthenware.
2. Boracic glaze—Granite ware, fine earthenware.
3. Tin glaze—Urbino ware. Della Robbia ware.
4. Silica alkali—Salt glaze stoneware.
5. Earth alkali, or feldspathic glaze—Porcelain enameled stoneware.

This plan of taking the composition of the glaze as the basis seems, on the whole, the most satisfactory, though it has one objection, viz., that it indicates neither texture nor density, because the proportion of the various ingredients is not taken into account, and results widely differing are therefore brought under the same heading. Each of these classes have their distinctive features, which need the attention of the ceramic decorator.

Lead glaze, for instance, is especially liable to trickle and run down the ware, and when compared with boracic glaze under the same conditions this is very evident. The latter, as shown here, keeps its position on the vase, while the lead glaze has run down. This is often the destruction of the underglaze painter's work, lines and bands being liable to slip down with the swimming and falling of the glaze.

Another peculiar property of boracic and soda glaze is the power it possesses of developing the color in turquoise enamels, and those rich *flambée* (*sang de boeuf*) effects which are so skillfully obtained in some of the old Japanese wares.

Tin enamels have a quality entirely distinct, producing characteristic effects on the design in which they are employed. The object of the opaque enamel is, in most cases, to obliterate the low color of the body beneath. Hence the thickness is considerable, and, inasmuch as the fusion of the glaze is not in all cases complete, the modeling of fine details is avoided. Hence the broad effects of all the Della Robbia work. Neither do the colors allow of any strong contrasts of shadow in the hollows, as is the case with colored glazes. The light being reflected only from the surface, there is a flatness and sameness of effect which, notwithstanding the splendid skill that has been devoted to the decoration, compels us to place it in a secondary position in the list of available materials.

For decorative purposes glazes may be broadly divided into colored or uncolored.

In Texture.—(1) Transparent; (2) translucent; (3) curdled; (4) opaque; (5) lustrous.

In Construction.—(1) Dead, or non-reflecting; (2) pitted, or egg-shell; (3) brilliant or vitreous; (4) bubbled; (5) crackled.

DECORATIVE VALUE.

Apart from these distinctive classifications, the decorative value of glazes in ceramic design is a matter of considerable interest, and it is the object of this paper to show that the glaze itself plays a very important part in the artistic result. Beyond this, it may also be demonstrated that the relative merit of various glazes is based upon certain optical principles which have been at present only partially examined by scientists, and that these principles which underlie the pleasurable sensations to the eye really govern that which we are pleased to call good taste and excellence, so far as glazes are concerned, and are not mere matters of opinion.

The value or utility of a glaze for decorative purposes is affected—

1. By its color.
2. By its fusibility.
3. By its construction.

1. *Color.*—The color of a glaze is obviously of the first importance. Here are various illustrations.

The purity of white seems to be less pleasing in the case of this vase than the ivory tone which blends more fully with the colors of the design.

Here the color of the whole is harmoniously assisted by covering the surface with this rich, warm orange glaze, blending with the happiest results, the tone of the design and that of the background, the contrast of which would have appeared raw and cold without it.

In this instance, again, the best possible effect has been secured for the decorator by dipping his work in a warm glaze, which, while softening the outline, has also given strength and tone to the whole.

In all these examples, the glaze has been used merely as a dip, covering the whole piece. But there are further uses of it, which have been much improved of late years, following the methods of majolica, Palissy ware, and the Grès de Flandres.

In all of them colored glazes are substituted for pigments, and penciled over various sections of the design, which is often modeled in relief. Examples of this are to be seen here.

It need hardly be pointed out that in the penciling of glazes by this method, the details of work are greatly limited. The glaze is generally thick, thus clogging to the brush, and it becomes somewhat unmanageable.

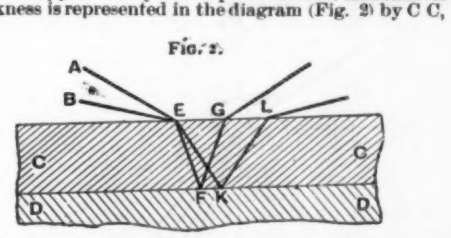
This suggests the query if an equally pleasing result may not be obtained by penciling pigments only, and dipping after in a transparent colorless glaze. But a moment's reflection will show that the value of the two methods is not by any means the same, and that while gaining in definition and ease of production, there is considerable loss in richness and mellowness of effect, and of satisfaction to the eye.

In order to demonstrate this, let any one place at the back of a plate of white transparent glass a piece of dark blue paper, and at the back of another thick plate of blue glass of the same tone and thickness, a piece of white paper. In a strong light, the comparison of the two will at once convince the observer that the tone and quality of color in the latter is greatly more pleasing.

Though it may not be possible to enter here into all the complex details of the amount of light absorbed, refracted, reflected, and scattered in the two cases, it is not difficult to show that what is thus apparent to the eye has its foundation in something more than an æsthetic opinion.

Let us presume, for a moment, that the colored glaze is dipped evenly over a piece of ware, and that its thickness is represented in the diagram (Fig. 2) by C C,

FIG. 2.



SHOWING PASSAGE OF LIGHT THROUGH GLAZE FROM TWO SEPARATE SOURCES.

the thickness of the ware being shown at D D; now, if a ray of light travels from A, through the colored glaze, at E, being reflected from the white background of the ware, at F; if, moreover, another ray of light travels from B, through the same glaze, and is reflected from the white background, at K, as before, the angle of incidence, in the latter case, is greater; consequently, the length of the pathway, E K L, traversed by the ray through the glaze must be much more than the length of the pathway, E F G. The depth of the color conveyed to the eye by the light passing from A is, therefore, less than that passing from B; and so on from all parts of the object illuminated, the tone value of the colors will appreciably differ in proportion to the angle, thus affording that true sensation of pleasure always resulting from nature's universal law of harmony in variety.

Reversing the method, and substituting a blue background at F K, and a transparent white glaze at C C, it will at once be seen, from the diagram, that the relative length of the path of light through the glaze, in each instance, will cause no variation to the tone sensation received by the eye, because the color of the ray is not in any way affected by its passage through the glaze, the result being that uninteresting uniformity of which the senses are so intolerant.

I am aware that I have left out of the question the absorption of part of the light, and the scattering of some of the rays, and the action of the convex surface; but I hope I may have been able to make clear

the principle involved, and thus to explain that which the eye intuitively appreciates, without the assistance of scientific demonstration.

2. *Fusibility.*—The second and equally important quality affecting the value of glaze is its fusibility, which greatly affects its power of refraction. All transparent glazes should be fused to the highest degree of temperature which they will bear without trickling down the piece; and, at first sight, it would seem that, provided the glaze is smooth and clear and evenly fused over the whole surface, difference of hardness or density will be immaterial, except on the score of durability.

Such, however, is by no means the case. The higher the temperature a glaze will stand, the greater the hardness; and the greater the hardness, the greater the power of refraction. The greater the refraction, the greater the brilliancy of the light reflected back to the eye, and the greater the pleasure appreciated therefrom.

If we place side by side a piece of glass, a piece of rock crystal, and a diamond, the form and facets of each may be the same, but the eye is immediately sensible of the different refractive value of each, and readily accords to the diamond the highest place.

Precisely the same result is arrived at by comparing raw faience glaze, a fritted earthenware glaze, and a Doulton ware or porcelain glaze.

The eye at once experiences the great superiority of the harder glazes.

Nor is the reason of this difficult to understand, though I am not aware that in this respect the relative power of the various glazes has been tabulated.

From the table below (Table 1) will be seen that the density and the refractive power increase very nearly in the same ratio, though it is a fact that the density and the hardness are not always the same, because the material of some soft glazes is very heavy.

TABLE 1.—INDEX OF REFRACTION OF CROWN AND FLINT GLASS IN THE D RAY.

Name of Glass.	Density.	Refractive Index.
Hard crown	2·485	1·517
Extra light flint	2·866	1·541
Light flint	3·206	1·574
Dense flint	3·658	1·622
Extra dense flint	3·889	1·650
Double extra dense flint	4·421	1·710

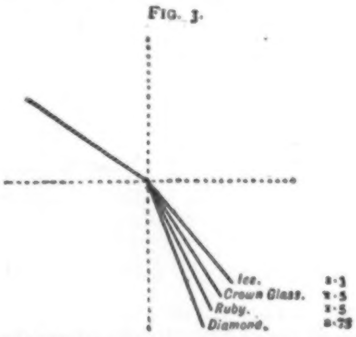
The diagram below gives the refractive indices compared for various densities and the angles set out for the diamond and other gems. (Fig. 3.)

TABLE 2.—INDICES OF REFRACTION.

Name of Material.	Refractive Index.	Density.
Diamond	2·75 to 2·47	3·5 to 3·6
Iceland spar	1·65	3·6 " 2·8
Topaz	1·61	3·4 " 3·6
Beryl	1·59	2·8 " 2·6
Emerald	1·58	2·8 " 2·6
Rock crystal	1·54	2·8
Crown glass	1·51	2·48

Now the light in passing from its source through the glaze to the surface of the piece is more or less refracted,

FIG. 3.

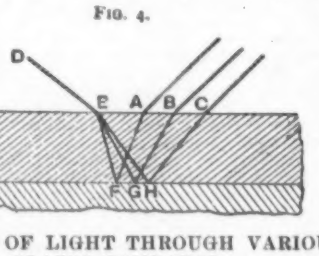


SHOWING ANGLE OF REFRACTION FOR GEMS, ETC.

and as a certain amount of light is absorbed in the passage through the glaze, it is clear that the rays passing to the eye by the shortest course will have the greatest brilliance.

It will, moreover, be found that the most infusible glazes are the most refractive, and, therefore, that the

FIG. 4.



PASSAGE OF LIGHT THROUGH VARIOUS GLAZES COMPARED.

glazes fired at the highest temperatures transmit the greatest amount of light to the eye.

From the diagram (Fig. 4) the comparison of the passage of light through the soft, medium, and hard glazes will readily be seen.

3. *Construction.*—Another and equally important consideration in the quality of a glaze is its construction or texture. This greatly affects its beauty, as upon it depends its translucence, or power of reflection.

(*a*). A glaze may be opaque, but it may reflect much light from its surface. Or

(*b*). It may be translucent, reflecting scattered light which has penetrated the surface. Or

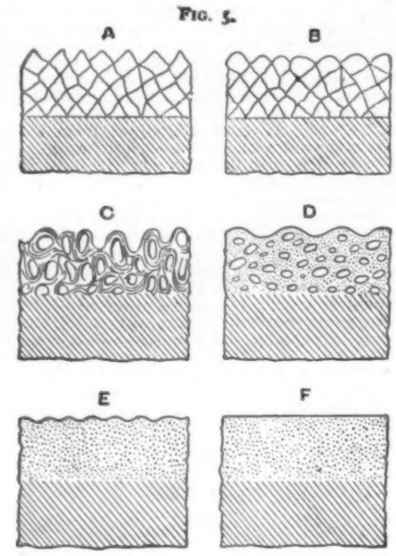
(*c*). It may be transparent, allowing the greater part of the light to pass through it to the ware itself, being reflected back to the eye from the background.

(*d*). And, further, it may be transparent in itself, yet loaded with opaque particles which partially reflect and partially scatter the light, often with the happiest effects and the richest beauty of result.

(*e*). In addition to all these, a glaze may have imported into it some peculiar quality from the incomplete mingling and fusion of the material, through intentionally firing to an insufficient temperature. This mostly happens with raw glazes.

To appreciate this, it is necessary to follow the history of a piece of glazed work through its various stages, as shown in the diagram (Fig. 5).

FIG. 5.



SHOWING VARIOUS STAGES OF FUSION OF A GLAZE.

A. The glaze being ground in water, is laid on the piece of ware, appearing irregular in surface.

B. In firing, the heat increases till the fusion commences by rounding the points. Then the glaze is termed "glanced."

C. Proceeding, if the glaze has not already been fritted, the incipient fusion causes certain chemical reactions which liberate gases, and these in escaping cause the surface to froth and bubble.

D. The gases having escaped, the surface becomes gradually smoother, but the mass is, nevertheless, often filled with small bubbles, which have not had time to escape before the heat has been checked. In this manner translucence is caused, or a general appearance of opacity, from the scattering and diffusion of the light.

E. It is only necessary to carry the heat higher to remove these bubbles and cause complete fusion, when a transparent glaze is obtained. To demonstrate this, I call your attention to this vase, which I have caused to be fired partially, with translucent result. The other half has been in a greater heat, and also received salt vapor on its surface to complete the fusion. It is by this operation changed to a glaze.

F. The glaze is, however, still "pitted," owing to the incomplete firing of the surface; and if sharply fired, the final brilliancy of reflection is attained.

Here I pause to note the marked excellence of the salt-glazed method as used for Doulton ware in accomplishing this result. We have seen that colored glaze rather than colored background gives richness of effect. Also that the greatest refraction results from the hardest fired glaze. But the hardest glaze is naturally that which is most difficult to bring to a smooth surface. To accomplish this smoothing of the surface, while maintaining the use of a highy refractory glaze, the salt vapor is resorted to, and this, while glazing every uncolored part, fuses the surface only of the color to a slight degree, and completes that beauty of reflection by securing the smoothest possible surface to the whole. Nor is this the only interesting matter to be noticed. In the case of other wares it is possible so to adjust the composition of the glaze as to cause it to fuse at any required temperature, irrespective of the hardness of the body. But no such arrangement is possible with salt glaze. It will be found that, only after securing a temperature sufficient to vitrify the body, is it possible to obtain a complete glaze from the vaporizing of the salt; so that a good salt glaze is in itself, to a large extent, a guarantee of excellence in quality of ware.

Doubtless, the difficulties and risks of manufacture are great, chiefly owing to the fact that it is necessary to expose the ware to the flame of the open fire. It is not, therefore, surprising that a process so difficult and needing such watchful care and experience in its completion, should have been gradually abandoned in Staffordshire in favor of the easy methods of dipped glazes and sagger burning; and it is greatly creditable to the enterprise of Sir Henry Doulton that, in the face of acknowledged obstacles, salt glazing has again been raised to the position of a fine art, so that its productions are able to vie with, and even surpass, the results of every age and country.

With the most perfect fusion the surface is never quite evenly covered with glaze, the reflected image being always somewhat distorted. Even this, however, gives additional pleasure, by breaking the monotony of the surface. It is only necessary to compare a piece of ware lapidary polished with a piece of ware glazed, to see that the mechanical surface is much less interesting.

By some designers this quantity of brilliant reflection of light from the surface is considered a detriment to the ware, because it is liable to interfere with the design, often entirely obliterating the effect of the work.

It is quite possible to avoid this objection by adopting any of the various expedients for breaking up the reflecting surface. In this example it will be seen that the plain glazed surface of the upper portion reflects the light freely; whereas the surface of lower portion being broken up by the impression of a very fine network is entirely free from this defect, although the whole vase is evenly covered with the same thickness of glaze.

The same effect has been secured by Messrs. Maw in their "Morocco" surfaced tiles, which are made nonreflective by a similar method.

This is a matter of much importance in ecclesiastical decoration. Strongly glazed tiles are open to much objection in obliterating the design by reflection. And the manipulation of enamels and glazes by dulling of the surface in painting and firing is a great gain, giving as in this panel all the effect of tempera work. On the other hand, it is equally possible for the skillful designer to lay hold of this quality of reflection and so add interest by emphasizing it.

Here is an instance in which the chief quality of the design depends on the high reflective power of the surface. It is only necessary to compare it with this unglazed piece of similar design to appreciate the great superiority of the former.

Doubtless all these various qualities, the subtile combination of which together constitutes the beauty of any given ware, may appear to be minute and even trifling, but the very minuteness of the variations, together with the complexity of the results, are in themselves a source of satisfaction. The extremely sensitive organism of the human eye gives it the power to appreciate the most delicate and subtile changes of light, color and form, and the sense of this power, as well as the very opportunity of exercising that refinement of discrimination, is in itself a means of infinite mental enjoyment.

As to the ear the musical inflections of the human voice are the means of ceaseless delight, so to the eye gradations of tone, color, translucence and reflection afford the unlimited possibility of pleasurable sensation; and for this reason they enable the potter to appeal with unfailing interest to the artist and the connoisseur.

It has thus been shown that excellence of glaze is greatly attributable to high firing, which adds brilliance and beauty to its texture. So much do the eyes become, in time, accustomed to appreciate this quality, that it is possible to form a fair estimate of it without close examination or handling the piece itself. Yes, after all, there is in this same excellence a pleasure even to the touch, and one begins to realize that the old joke of "living up" to a piece of blue china is not so far fetched after all; and the collector who goes about fondly stroking a choice piece of "Nankin" has, notwithstanding all our smiles, strong arguments in favor of his fond appreciation.

There is still another point which demands attention before leaving this part of the subject, viz., the scattering of light, due to the character of the background immediately underlying the glaze; a matter which, in its influence on the artistic result, is by no means unimportant. It must be evident to all that it is possible to leave the unglazed surface of the ware in a variety of conditions before covering it with glaze.

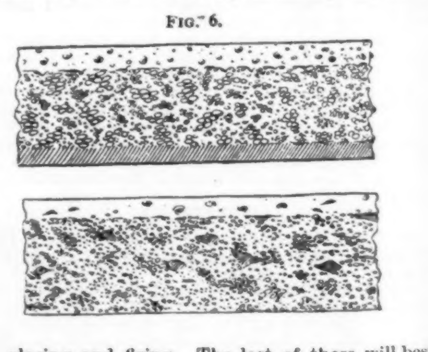
(*a*.) It may be roughly formed without any attempt to smooth it carefully; or

(*b*.) It may be completely burnished, so that the surface is to a great extent impervious to the glaze fusion; or

(*c*.) The surface may be purposely formed of coarse granular particles, leaving an irregular formation on which the glaze is deposited, and into which it fuses.

Here are specimens of all these methods, and the diagrams (Fig. 6) will show approximately the result

FIG. 6.



after glazing and firing. The last of these will best illustrate the scattering of rays, viz., the Persian tile, in which the background is almost crystalline.

It has been customary to make these tiles of about 90 per cent. of coarsely ground fragments of silica or rock crystal, cemented together by about 10 per cent. of clay and glass. In the case of Damascus tiles this is a pure white frit, mostly glass and alkali. The surface of the tile so formed is naturally very irregular, and the glaze fuses into the interstices, forming a background which partly scatters the light with that charming effect so well known and admired. It is only needful to compare these examples with the modern French imitations, or with Dutch enamel tiles, to see how far more artistic is this effect of the former.

With regard to the blending of the background into the glaze, this is much affected in all cases by the preliminary treatment of the ware. If the glaze has been fritted and the ware biscuited, there is much less intermingling and fusion of the two at the surface of contact. But in cases where the body is unburnished and is fired with a raw glaze upon it, at one operation, the line of demarkation between the two is very undefined, and the result proportionately softer in effect. It is

probable that much of the beautiful Japanese Celadon ware is produced by such means.

The soft translucence of porcelain is greatly due to this intimate blending of the glaze and body, uniting the whole into one mass, having no sharply dividing line between the two, so that when the light penetrates the transparent glaze it is reflected and refracted from the surfaces of the minute crystals resulting from the combination of the clay body with feldspathic flux.

In beauty of texture, the material is unsurpassed, uniting, as it does, all the highest qualities of the potter's art; an enduring evidence of the triumph of human skill and persistence in conquering the most serious obstacles which stand in the way of its successful production.

It is hardly necessary to remind the decorator that the material to be employed, as well as the tools and appliances for carrying out the work, must greatly modify the treatment. Especially is this remark true in respect of pottery glazes. The design which might prove admirably suited for underglaze work on bisque must be wholly unfit for painting on raw enamel; and, for many reasons, an artist is compelled to inquire, before proceeding, the nature of the glaze to be used for the completion of his work, unless he wishes to run the risk of hopeless disappointment in the result.

It is from this consideration only that I have ventured so fully to enter into details which, in themselves, may appear somewhat unimportant.

DECORATIVE APPLICATION.

Having thus far treated of the characteristics which, for purposes of decoration, give value to a glaze, and, at the same time, attempted to explain some of the principles to which those peculiarities are due, I may perhaps be allowed to draw attention to a few examples of the successful application of various glazes on the embellishment of pottery.

A.—Subordinate Treatment.

In many instances the designer is naturally led to subordinate the glaze entirely to the main features of his work, using it as a means of adding brilliance to his result, or of imparting a soft translucence. A comparison of the two methods is furnished by these beautiful examples of Worcester porcelain, and that of Messrs. Copeland. In the first, the ivory-toned ground is made the field upon which gold enrichments have been added, the translucence greatly assisting the beauty of effect; while, in the latter, brilliant transparency and purity of the glaze serves to give piquancy to the whole; or, to take another instance, it is interesting to note the same skillful subordination of glaze to its purpose in the treatment of this exquisite design by M. Solon. The soft and tender fading of the half tones into the background is greatly enhanced by the rich glazing, which, however, does not interfere with the delicate modeling of the subject. Comparing this, again, with the vase here shown, designed by Flaxman, it is not difficult to apprehend the reason for the different treatment of the modeling adopted. Having no intention of glazing, the artist has trusted alone to the pleasant translucence of his material to overcome any harshness of effect. Looking at the two examples, one feels that it would be as unpardonable to add the glaze to one as to remove it from the other.

It must occur to the least initiated that the comparison of advantages in painting over or under the glaze is most important to the ceramic designer.

For endurance, and for softness of tone, the underglaze system is undoubtedly superior; nevertheless, the palette thus becomes limited, and many otherwise available effects must therefore be discarded. Moreover, in some cases the placing of color or gold over the glaze heightens the beauty by enabling the eye to more fully appreciate the translucence or the thickness and tone of the glaze beneath.

In this example, the gilding on Doulton ware glaze gives a sense of satisfaction from the same cause.

Equally pleasing is the gilding on this vase of "Crown Lambeth" ware, which also affords an illustration of a somewhat different manipulation.

The design mostly painted on the biscuit is, after glazing and firing, retouched and worked up with underglaze color, being again glazed and fired at the same heat. The blending of the finishing color with the glaze, in which it is thus entirely embedded, while affording some considerable risk for the decorator, gives a soft and mellow gradation of tone which can hardly fail to commend it.

Midway between the "subordinate" and what may be termed the "principal" use of glaze as a decoration, one finds a class of treatment involving the use of glaze in harmonizing or mellowing the tone of the whole design by a variety of methods. The simplest of these is, perhaps, the adoption of a "crackle glaze," as in the well-known Satsuma ware. It is not necessary to expend time in explaining the different adjustment in shrinkage of the body and glaze which causes this. It may be sufficient to point out that, in cooling, the whole surface is broken up into a network of small cracks. The reflection of light thus obtained on the edges of the fractures acting as facets breaks up the plain surface and tends to add brilliancy as well as harmony to the whole. A good example of this effect is to be found in many of the wall tiles produced by Mr. De Morgan.

Another expedient for the same end is to be formed in the covering of the surface with a colored glaze, giving a certain tone to the whole as previously mentioned.

In the example here shown, the beauty of the work is greatly enhanced by the rich green glaze in which it has been dipped.

A third method is illustrated by this piece of Lambeth Carrara ware. A white background is decorated in green slip, the hard contrast of the two being subdued by covering the whole with a semi-opaque glaze, which tones the color while it emphasizes the brush modeling.

B.—Principal Treatment.

Passing on to the use of the glaze itself as a principal decoration, we note many interesting and ingenious adaptations.

The use of broken color alone, combined with small crackle, affords the *motif* for the well-known and much prized tortoiseshell ware of Wedgwood, as also in the beautiful specimen of Aventurini glaze of French manufacture, resulting from the combination of iron and copper with an alkaline glaze. Also in these reproductions of the Japanese tea jars in Doulton ware.

The lustrous surface gives sufficient interest to the beautiful production of Beleek and other similar pottery, while the movement of the surface is illustrated in this specimen of the ware of Japan; and in this we have another very peculiar and striking instance of glaze treatment.

The glaze, having crazed at an early stage of the firing, gradually contracts until each minute section shrinks away from its neighbor, and becomes a small round drop, giving the whole the appearance of peach stone or nutmeg surface.

A further and striking development of the same idea is here shown in another method. The glaze is first of all formed into small, glassy beads, and these are embedded in a coating of glaze dipped on the pot while the same is wet. After firing, the refraction of light gives from some points of view a very singular and brilliant result.

Here, again, is an altogether different adaptation of the material instanced in these delicately skillful productions of Messrs. Minton. After finely perforating a design in the ware, the piece, when fired, is discovered with a glaze sufficiently thick to fill the interstices with the most charming and artistic result.

Almost all the above have as their basis the desire to produce satisfaction to the eye by variety and contrast through the breaking of the surface of the color of the glaze.

A very happy and extremely delicate combination of both treatments is well illustrated by the "mother-of-pearl" background, a clever and ingenious texture lately produced on Messrs. Doulton's Burslem china. Its iridescence, although apparently similar to luster, is altogether distinct in the method of production, as will be seen on close examination.

Altogether different from the modes already named is the filling of an intaglio design with a soft glaze. The ware is horizontally fired, and the colored glazes flowing to a uniform level during fusion, produced a shaded effect, according to the varied depth of the design.

Here are very characteristic examples of this method.

A similar operation, but upon a modeled surface, is here adopted.

It has been my desire in thus limiting attention to one section only of the potter's work, to arouse, at the same time, in the ceramic designer a wholesome pride in his material and a true respect for his handicraft.

Nothing short of complete excellence and thorough honesty of workmanship in the potter's art can withstand the searching test of that extreme fire necessary to produce the most perfect and enduring result; and, as in other spheres of life so in this, disintegration is the ultimate penalty of all that is false, and superficial, and immature.

Nor is it possible to avoid the conviction that for the attainment of the highest perfection, there must be added to this honesty of purpose that absolutely harmonious co-operation of each toward the final result which is the truest ideal of human existence.

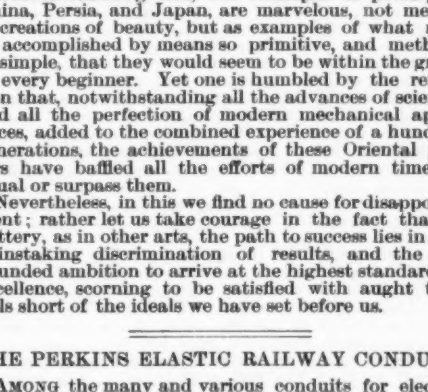
Pottery consists of a chain of operations, in which there are many links; each process in itself complex, and in its principles far from completely comprehended. Yet the failure of any single link brings disaster and dismay, wrecking the willing work of all that have gone before.

Notwithstanding this, the triumphs of pottery in China, Persia, and Japan, are marvelous, not merely as creations of beauty, but as examples of what may be accomplished by means so primitive, and methods so simple, that they would seem to be within the grasp of every beginner. Yet one is humbled by the reflection that, notwithstanding all the advances of science, and all the perfection of modern mechanical appliances, added to the combined experience of a hundred generations, the achievements of these Oriental potters have baffled all the efforts of modern times to equal or surpass them.

Nevertheless, in this we find no cause for disappointment; rather let us take courage in the fact that in pottery, as in other arts, the path to success lies in the painstaking discrimination of results, and the unbounded ambition to arrive at the highest standard of excellence, scorning to be satisfied with aught that falls short of the ideals we have set before us.

THE PERKINS ELASTIC RAILWAY CONDUIT.

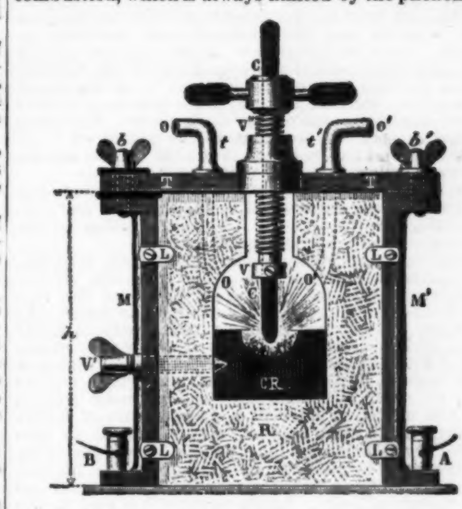
AMONG the many and various conduits for electric street railways, that recently designed by Mr. F. C. Perkins, of Buffalo, N. Y., possesses the merit of simplicity and cheapness of construction. The illustration shows the principle involved. The bare conductor is mounted on a stringer of wood impregnated with oil or some other insulating substance, and entirely surrounded by a flexible metallic tube. The current collector carried by the car presses this tube downward, making contact with the conductor and completing the circuit. The conductor is thus absolutely protected from water, mud, etc., and perfect insulation maintained.



THE PERKINS ELASTIC RAILWAY CONDUIT.

ELECTRIC LABORATORY CRUCIBLES.

UP to the present we have not had, in the usual equipment of laboratories, any apparatus for the study of electro-thermic reactions. Messrs. Ducretet and Lejeune have recently supplied this want in the creation of models, which are derived from the Siemens electric crucible, and with which are set in play both the electric current and the chemical affinities that require very high temperatures. In permitting of easily obtaining such temperatures, electricity offers a most interesting field of study that seems as if it ought to lead to very fecund results. The conditions of reaction of the bodies in presence are here entirely outside the pale of what can be realized by simple combustion, which is always limited by the phenomena of dissociation. Besides, the electric current itself plays a role that is called upon to give rise to reactions that are absolutely unhoped for with the electro-thermic processes.



In the accompanying figure, we represent the simpler of the two models of crucible constructed by Messrs. Ducretet and Lejeune. In a nearly square block, R, of refractory clay, 0·15 m. in height by 0·13 in width, there is an aperture 0·04 m. in height by 0·06 in width, at the bottom of which is placed a charcoal crucible, C R. The block, R, rests upon a slate base and is provided with two lateral pieces, M M, that carry screws, L, which hold in place plates of mica designed to hermetically close the openings through which the crucible is introduced. There is thus obtained a perfectly closed chamber whose sight holes permit of following the reactions during fusion and of effecting the spectral analysis thereof.

The tubulures, OO', allow a gas to circulate in the reaction chamber. Through another aperture, not figured, there may be introduced the substances upon which the electric current is to act. Our figure clearly shows the mounting of the carbon pencil, C, which is held in the hollow screw, V, through the tightening of the screw, V'. In this way, it is possible to give the carbon a rapid or slow double motion, according to the requirements of the regulation, and which permits of easily modifying the length of the arc.

It is through the binding screw, V', that the crucible is put in electric communication with the terminal, B, of the current collector. The armature of this screw, too, is insulated from the apparatus by ebonite plates between which is tightly held the cap, I, that serves as a metallic connection between the screw, V', and the other terminal, A, of the current coming from a dynamo or a series of batteries or accumulators.

In the second model of electric crucible, two carbons, C, are arranged obliquely so as to make an angle of about 90°. The extremity of these carbons comes into contact in the interior with a crucible, C R, of very refractory material placed within a jacket of refractory clay which prevents a loss of heat through radiation. The circulation of the gases and the introduction of the substances to be studied are provided for by apertures arranged for the purpose. The faces are closed as we have above seen. A current of 12 amperes and 35 volts at the terminals suffices to obtain the temperature necessary for the rapid fusion of aluminum and the production of small rubies and of aluminum bronzes by the Cowles process.

In order to bring the arc that forms between the two carbons into immediate contact with the substance in the crucible, the latter is simply placed between the branches of a small horseshoe magnet weighing about two kilogrammes. Owing to the action of the poles of this magnet, which constitutes a magnetic field in which the arc forms, the latter so elongates itself that an arc of 3 mm. is transformed into a continuous flame of more than 20 mm. in length. The circulation of the poles of the magnet depends upon that of the current in the arc.

On changing the position of the magnet, we displace the flame of the electric blowpipe, and thus transfer it either to the bottom of the crucible or elsewhere. This is a new and very ingenious application of the phenomenon utilized by Jamin in his electric lamp.

Upon the whole, these laboratory crucibles will permit chemists and metallurgists to perform a whole series of electro-thermic experiments whose results will be interesting and new.—*Revue Industrielle.*

A NEW ELECTRICAL FURNACE.

By M. HENRI MOISSAN.

THIS new furnace is made of two carefully plane pieces of quicklime, one placed under the other. In the lower one is a longitudinal groove for the two electrodes, and in the middle is a small cavity more or less deep acting as a crucible; it contains a layer of a few centimeters of the substance to be acted upon by

the arc. A small carbon crucible may also be placed in it containing the substance to be calcined. In the reduction of oxides and the fusion of metals, larger crucibles are used, and through a cylindrical aperture in the upper brick small cartridges of the compressed oxide and carbon can from time to time be added. The diameter of the carbons which act as conductors will of course vary with the strength of the current; after each experiment the end of the carbon is changed into graphite.

The current most frequently used was one of 30 amperes and 55 volts; the temperature did not much exceed 2,250°. A current furnished by a gas engine of 8 horse power was 100 amperes and 45 volts produced a temperature of about 2,500°. Finally, thanks to the courtesy of M. Violle, we had at our disposal 50 horse power; the arc in these conditions measured 450 amperes and 70 volts, the temperature was about 3,000°.

With high tension experiments certain precautions must be taken and the conductors be carefully insulated. Even with currents of 30 amperes and 50 volts, like those used at the beginning of the investigation, the face must not be exposed to a prolonged action of the electrical light, and the eyes must always be protected by means of very dark glasses. Electrical sunstrokes were very frequent at the outset of these researches, and the irritation produced by the arc on the eyes may produce very painful congestion.

The temperatures given are only approximate; they will be especially determined by M. Violle by methods to be afterward described. A certain number of the results obtained are briefly enumerated.

When the temperature is near 2,500°, lime, strontia, and magnesia crystallize in a few minutes. If the temperature reaches 3,000° the substance of the furnace itself—quicklime—melts and runs like water. At this same temperature carbon rapidly reduces calcic oxide, and the metal is liberated freely; it unites readily with the carbon of the electrodes, forming a calcic carbide, liquid at a red heat, and which can be easily collected. Chromic oxide and magnetic oxide of iron are melted rapidly at a temperature of 2,250°. Uranium oxide when heated alone is reduced to protoxide, crystallizing in long prisms. Uranium oxide, which cannot be reduced by carbon at the highest temperature of our furnaces, is reduced at once at the temperature of 3,000°. In ten minutes it is easy to obtain a regulus of 120 grains of uranium.

The oxides of nickel, cobalt, manganese, and chromium are reduced by carbon in a few minutes at 2,500°. This is a regular lecture experiment, not requiring more than a quarter of an hour.

By this method we have been able to cause boron and silicon to act on metals, and thus obtain borides and silicides in very beautiful crystals.

This investigation is being continued.—*Comptes Rendus, Dec. 12, 1892; Phil. Mag., March, 1893.*

TELEGRAPH IN WAR.*

By Lieut. Jas. A. Swift, 9th U. S. Cavalry.

Literally speaking, telegraphy signifies the art of writing at a distance, or the sending of signals from one distant point to another.

During the world's history various methods of telegraphing have been employed, all of which have depended on either sound or light as agents. The most primitive was by lighting fires at different intervals on commanding positions, and, later on, by firing cannon, the latter being considered an improvement over the former, inasmuch as its value would be the same at night as in the daytime, and the transmission of more varied information could be effected.

The semaphore system was also made use of, certain prearranged meanings being expressed by the different positions of cross arms attached to uprights, or posts, on different hill tops.

These methods of transmitting or signaling communications, although very defective, were the best that were known until electricity, overcoming all objections, came to be used for this purpose. To illustrate the importance of the telegraph in war and all that pertains to war is the object of this paper.

During the late civil conflict in this country the usefulness of the electric telegraph was most fully developed, and the operators and others engaged in the United States Military Telegraph Corps, whose services were so essential in connection with military operations, are justly entitled to a share of the credit conferred by Congress upon the army.

Referring to the military telegraphers in the war, General U. S. Grant in his memoirs makes this short but pointed remark: "Nothing could be more complete than the organization and discipline of this body of brave and intelligent men."

Speedy communication with all points is a matter of the greatest importance in war, and although the electric telegraph supplies the means, yet no nation is patient enough to await even this, the most speedy of all methods, for supplying the news of battle and of the forces engaged.

During our civil war the entire country was informed by telegraph of each battle fought, and of the results; and frequently as to how the battle was progressing even before either of the contending armies had won the fight or knew which side would be the winner. Many were the heroic deeds of the operators and others engaged in the telegraph service, in maintaining communication with the armies to which they were attached.

Secretary Stanton in his annual report for 1863 says: "The military telegraph has been of inestimable value to the service, and no corps has surpassed, few have equaled, the telegraph operators in diligence and devotion to their duties."

Other means of communication were employed during the late war, among which might be mentioned the balloon, the carrier pigeon, and the flag and torch. The heliograph and telephone had not then come into use.

The English army, it is said, was the first to use field telegraphy. In the Crimean war their trenches and batteries before Sebastopol were traversed and connected by lines of telegraph. The French soon followed their example by constructing a similar system, and, later on, a cable laid across the Black Sea put the armies in the field in direct communication with London and Paris. Since then a regular telegraph corps has been organized in every European army.

It was the telegraph that enabled General Grant, from his headquarters in the field, to move his armies understandingly, as in one vast game of chess, and which brought to him dispatches daily of the doings of his generals from all parts of the seat of war.

Never before in the history of war did one man direct so completely the several distinct armies, numbering over a quarter of a million soldiers and separated by thousands of miles, directing each day's operations by telegraph, and receiving reports at night by the same source that his orders had been received and obeyed.

During the battle of Spottsylvania Court House, Virginia, when General Hancock was being hard pressed by superior numbers, he telegraphed to General Meade that "If the Sixth Corps does not attack at once, I cannot hold the ground already gained." Meade promptly telegraphed General Warren, and in ten minutes after the dispatch was sent the Sixth Corps did attack and Hancock held his own.

Military telegraph lines were constructed during the war over an extensive territory, embracing the District of Columbia, Pennsylvania, Ohio, Indiana, Illinois, Maryland, Delaware, Virginia, West Virginia, North Carolina, South Carolina, Louisiana, Mississippi, Alabama, Arkansas, Tennessee, Kentucky, Missouri, Kansas, and the Indian Territory, making in all 15,389 miles of line, at a cost of \$3,219,400. The number of telegrams transmitted was at the rate of 3,500 each day, and they varied in length from ten to a thousand or more words each, all being of an urgent or important character bearing upon military operations.

With a well organized and equipped telegraph system there is no reason why each army corps, division, and brigade headquarters should not maintain uninterrupted telegraphic communication with the commanding general. This could be maintained even while on the march, if desired, by making a halt at stated intervals, say from thirty minutes to one hour, and making reports of any changes with the advance that might occur, or any changes in orders from headquarters to the advance or rear of the army. In each military department the wires should radiate from the center or headquarters of the commanding general to each camp or outpost, and if either of the radiating lines should become interrupted, it would not interfere with the others. Each would be independent of the other, and telegrams passing over either of them could not be heard on the others, yet all could be connected as one circuit if desired at any time by the central, or headquarters, office.

The entire telegraph corps, including the chief and his assistants, should be practical electricians and thoroughly efficient operators. The supplies necessary for the equipment of the lines and their maintenance should be obtainable through the quartermaster's department. In each military department there should be an ample supply of wire, including No. 14 galvanized iron for the more permanent field lines, and insulated copper wire for the shorter or temporary lines. Also insulators, brackets, submarine cable, instruments, battery material, poles and tools, including reels for paying out the wire. The poles should be 17 or 20 feet in length, two inches in diameter, of light but durable timber (juniper if obtainable). The labor for putting up the line will be supplied by the troops if necessary, but it would be better to have an organized gang of laborers for this duty, so as not to draw on the troops except for such force as might be required from time to time to protect the working party. Ten miles, or even more, of field telegraph can be erected in half a day. As the army changes position the line could be taken down and the material loaded on wagons provided for the purpose, the wagons moving with the army. Insulated wire is best for short temporary lines, such as would be erected on the field during an engagement, as, in case of the line being knocked down by artillery or wagon trains, there would be less danger of interruption by contact with the earth.

The wire, whether insulated or naked, should be wound on reels, making about two hundred pounds weight of wire to each reel. Two men and one mule should be assigned to each reel, which should be attached to a pack saddle placed upon the mule's back. This pack saddle should be provided with a rack like a saw buck, placed crosswise of the saddle, and raised above it, so that the reel, with its wire, will revolve freely as the mule moves forward.

One wagon, to be used as an office in the field, with one operator, battery, instruments, and such other material as may be necessary, should be detailed for each corps, division, or brigade, and for the commanding general. The poles should be loaded on truck wagons, fitted with standards. Each pole should be fitted with an insulator (hard rubber) at one end, the insulator being slotted so as to hold the wires up when raised.

The mules for paying out the wire should be assigned to brigades, and always kept with the command to which they are assigned. The operators should be assigned to certain headquarters and never changed except in case of urgent and immediate necessity. The moment the troops go into camp, all the force connected with the telegraph service should proceed to erect the wires.

A mule loaded with a coil of wire, as previously described, should be led to the rear of the nearest flank of the brigade he belongs to and then parallel thereto, with one man to hold the end of the wire and uncoil it as the mule is led off by the other man. This should be done in rear of each brigade at the same time, and the ends of the wires spliced, making a continuous wire in the rear of the whole army.

The men attached to brigades and divisions should all commence raising the wires at the same time. This is to be done by placing the wire in the slot of the insulator and raising the pole to a perpendicular position. In order to avoid too much slack or sag in the wire, it should be attached to a tree or some other permanent fixture at intervals of about every 500 yards and pulled up taut. In the absence of any permanent support, two poles should be used instead, at intervals, and placed at an angle, with the tops secured together so as to hold the wire firm in its place and at the proper tension. This should invariably be done at all sharp angles. Otherwise the pole will bend, or give, and cause the wire to sag too much, rendering it liable to be caught by wagons or artillery and pulled down. While the line is being put up the telegraph wagons, with the operator, etc., should take their positions near where the headquarters to which they belong are to be established, the necessary connections made and the office opened for business. Thus in a few minutes longer time than it would take a mule to walk the length of its coil of wire telegraphic communication could be effected between all the headquarters of the separate armies. Each construction party should be under the immediate supervision of a foreman. There should also be a chief operator for each separate army, who should be located at the headquarters of the commanding general. A portable battery for supplying the electric current for charging the wires was used in the field during the war, and consisted of 16 sections of 6 cells each. The cells were made of copper, about four inches in diameter by nine in depth, and contained a solution of sulphate of copper. In the liquid was placed a leather cup one-half of the diameter of the copper cell, and this contained a zinc plate and water, the outer, or copper cell, being the positive pole and the zinc plate the negative pole. Each cell was insulated by a casing of thin sheet rubber, and fitted on the top with a bone rubber cap to make the cells water tight and prevent the spilling of the fluid. Each section of battery was inclosed in a strong box and the whole securely packed in an escort wagon. There was also stored in the wagon a supply of sulphate of copper and zinc plates, the only articles necessary, except water, to replenish the battery and keep it in working order.

The operator's table, instruments, stationery, tools, battery, etc., were placed in one wagon, thus forming a complete outfit for working one or more lines at a moment's notice. This arrangement answered all purposes, and perhaps up to this time none better could be devised, but with the rapid and numerous improvements in telegraphic apparatus, it is difficult to predict what may be introduced in time to come.

All important telegrams concerning military movements should be in cipher, to prevent disclosure in case they should fall into the hands of the enemy. The cipher key should be frequently changed. This mode of secrecy was invaluable to the government and of great advantage to military operations during the late war.

While the field telegraph affords the military commander a rapid and certain medium of communication with his base of operations and the various corps of his army, it must be remembered that it is at the same time one which is continually liable to interruption by an enterprising enemy. Wherever a military commander has to contend with an army well provided with efficient cavalry, he will find it extremely difficult to protect his telegraph lines from being destroyed by daring raids of his opponents.

There are several easy ways of making a telegraph line temporarily useless. The simplest and most obvious method is to pull down the poles and cut the wires into pieces, but when this is done the damage is easily discovered and repairs quickly made. The interruption can be made far more serious if effected in a manner which will not permit of its exact locality being known or readily discovered; for instance, such as cutting the wire and introducing a piece of gutta percha, or some other non-conductive substance into the circuit, and then connecting the ends of the wire with it, so as to give it the appearance of the ordinary joints or splices. If, as a blind to this, a few poles were pulled down in another place and the wire cut, the probability is that the repair man would not discover the principal cause of interruption until he had restored the latter and returned to his station. Here he would find that the trouble still existed and was really more perplexing than ever, and that its location could only be determined by climbing every pole or by means of tests by the galvanometer.

There are other dangers to guard against. If the enemy's cavalry get possession of a telegraph station, they can, if accompanied by an operator, easily send messages containing false information or delusive orders to well known officers of the opposing army, while the place from which they are sent and the assumed name signed to them will give the messages an appearance of authenticity which, if it does not completely deceive the recipient, will at least be the cause of considerable doubt and perplexity to him, and perhaps cause him to hesitate to accept accurate information or authentic orders, when actually received from proper sources. These dangers should be guarded against as far as practicable by efficient patrol of the telegraph lines and by careful testing. "Tapping" the wires by operators of both the Federal and Confederate armies was not unusual. Little information was gained, however, from the cipher dispatches, but it sometimes happened that important discoveries were made as to the whereabouts or intended movements, strength, etc., of the opposing forces. General Crook, while in command in the Shenandoah Valley, Va., during the war, sent his operator to tap the Confederate telegraph wire near Shannon's Cross Roads, and ascertain if possible what force was in his front. The wire was "tapped," but owing to the peculiar style of handling the telegraph key by the Federal operator, suspicion was aroused in the minds of the Confederate operators, and they declined to answer any questions. One of them, however, indiscreetly remarked that "If that Yank don't hurry up and skip out, General Jenkins will get him." This indicated that it was the Confederate General Jenkins' command, the very information desired by General Crook.

During General Grierson's raid into the enemy's country from Memphis, Tenn., in December, 1863, he struck the Mobile and Ohio Railroad and sent his operator with an escort of 200 troopers to tap the enemy's wire near Corinth. Important telegrams were intercepted announcing the coming of re-enforcements, which information proved to be authentic and of great value to General Grierson. During Sherman's march to the sea his operator tapped the Confederate telegraph line running to Augusta, Ga., and worked with the latter office nearly a half day. It is believed, however, that his presence on the wire was detected, as the telegrams intercepted proved to be bogus and sent purposely to deceive. One telegram purported to be from General Longstreet to General Wheeler, at some point south, saying: "I will leave here in the morning with

* Read before Officers' Lyceum at Fort Robinson, Neb., Jan. 30, 1893.—From the *Journal of the Military Service Institution.*

10,000 men." Other messages of the same character were received. Deception, however, is a part of the art of war, and most of the prominent officers, on both sides, profited by deceptions of this nature practiced by their telegraph operators.

The most successful wire tapping of the war was accomplished by one of General Lee's Confederate operators. General Lee was anxious to learn of the purposes of General Grant. The tapping of the Fort Monroe wire was suggested. A Confederate operator with a company of picked men was chosen for the hazardous undertaking. The United States military wire was struck near Surry Court House, Va. The operator attached his instrument to the main line by means of fine silk-covered wire. This he ran under the bark of the telegraph pole to the ground, thence along the ground some distance in the woods, covering the wire with leaves. Thus was the Confederate commander placed in direct communication with the War Department in Washington. For six weeks this connection was maintained, and although many telegrams were intercepted and forwarded to General Lee, only one proved of value to the Confederates, owing to the efficient cipher system used by the Federal authorities. The one message, however, was of great benefit to the enemy. It was not in cipher, and was from the quartermaster in Washington, requesting that a guard be sent to meet 2,400 head of cattle at Coggins' Point, and convoy them to City Point for the Union army. Accordingly a strong force of Confederate cavalry was dispatched and arrived at the designated place in time to intercept the cattle and convoy them to the Confederate camp.

Wars, though less frequent, still occur, but the methods of conducting them are changed. If the ingenuity of man has provided weapons of offense and defense in superiority over the bow, the sling, and the shield, it has also produced means of conveying intelligence far more efficient and swifter than the runner, the voice, and the beacon.

A STEEL SHIP STRUCK BY LIGHTNING.

THE owners of the Capella, a steel steamer of 2,000 tons net register, record the following account of a remarkable lightning storm experienced by Captain Woodcock. The Capella is a steel steamer of 2,036 tons net register, having two masts, the lower masts being of iron, the top masts of wood. The steel wire rigging (served over) is carried to within about 3 ft. of the trucks, but there appears to have been no special lightning conductor fitted.

The incident occurred on May 16, 1892, in lat. 28·12 N., long. 70·50 E.: "The morning was squally, with rain and thunder and lightning; about half-past seven the storm seemed to have passed over, and the weather showed signs of clearing up, when after a considerable interval there was a very vivid flash of lightning, accompanied by a violent explosion by the rail, near the starboard fore rigging, which seemed as if something had exploded and scattered sparks and fire over the ship. The fore topmast was splintered near the spire, and some service torn off the top-gallant backstay. The shock also affected the compasses; that on the upper bridge was deflected from N. 72° W. to N. 45° W., and remained for a short time that way. The wheelhouse compass, which previously had shown W.N.W., now showed E.S.E., and the compass on the poop was considerably affected also. After trying another compass card in the wheelhouse, found the card was not affected, but the shock had changed the magnetism of the ship so much that it reversed the card. The westerly deviation of the upper bridge compass was later on found to be increased from 9° W. to 19° W. on the course steered (N. 72° W.) At 4 P. M. swung the ship completely round, and found the errors of the compasses very much altered: the deviation on the north was altered from 6° W. to 27° W. It was found after the ship was turned round that the wheelhouse compass had regained some of its original power, as the north point again pointed somewhere toward the north. Since the occurrence the compasses have never regained their original errors, and the magnets have had to be moved, and some reversed, to reduce the errors and make them easier to be applied."—*Sydney Morning Herald.*

GILBERT'S "DE MAGNETE."

DR. GILBERT'S great work "De Magnete" was published in the year 1600. It cost the eminent author 18 years of study, inquiry, and experiment; and all judges admit it to be an original, comprehensive, and masterly production. Although it produced a profound sensation throughout Europe, and although it was admired by such men as Sir Kenelm Digby, Barlowe, Kepler, Galileo, and Humboldt; though Priestley calls Gilbert "the father of electrical science," and Poggendorff "the Galileo of magnetism" yet nearly 300 years were allowed to elapse before "De Magnete" found a translator, and that not in this country, but on the other side of the Atlantic.

It is true that a "Gilbert Club" was formed in London in 1889 for the laudable purpose of clearing English science from the reproach of apparent neglect of one of England's greatest worthies; and in consequence of this revived interest in Gilbertiana we have a scholarly memoir of Dr. Gilbert from Mr. Conrad W. Cooke, which was published some time since in our columns (see *Engineering*, vol. xlviii., pages 717, 729), and an interesting magazine article from the pen of Dr. B. W. Richardson. But the long promised translation, the ostensible purpose for which the "Gilbert Club" was formed, has not been issued, and, indeed, its publication now would seem to be superfluous.

For our transatlantic friends have been before us and they have sent us as a token of their admiration of Gilbert's genius a carefully made translation of the lifework of the Colchester philosopher.

To turn into elegant English an ode of Horace, or an epistle of Ovid, or an oration of Cicero, is an undertaking worthy of a student for university honors; but it requires more than familiarity with the Latin tongue to do justice to Gilbert. The phenomena and experiments he describes are for the most part novel, and he himself is often driven "to employ words new and unheard of," not to veil things in pedantic terminology, but that "these things may be plainly and fully published." It is not surprising, then, that Mr. Mottelay, the able translator of "De Magnete," found his task to be one of "no ordinary difficulty," and that despite the aid of "many literary and scientific friends," he was left to do much close thinking and prolonged comparative research; for "De Magnete" requires the erudition of a scholarly interpreter rather than the literary facility of a mere translator.

The six books into which "De Magnete" is divided are preceded by 54 pages of explanatory matter. From them we gather that Gilbert led a quiet, uneventful life while pondering over his *magnum opus*. He instinctively realized that study and research cannot be carried on in the glare of society, in the throbbing excitement of public life, or even amid the multiplied cares of a professional career. When honors came to him, and he was made physician to Queen Elizabeth, he struggled hard to continue his researches, but almost in vain.

Gilbert discovered for himself that real scientific knowledge must be based upon experiment and observation. He tells us in his preface, with a little vein of pathos, of "the pains and sleepless nights and great money expense" his treatise cost him. His was, indeed, a true inductive method. "He speaks of phenomena like a genuine inductive philosopher," says Whewell,* "reproving those who before him had 'stuffed the booksellers' shops by copying from one another extravagant stories concerning the attraction of magnets and amber without giving any reason from experiment.'" For instance, he reproves Baptista Porta, an eminent Neapolitan, for saying that iron rubbed with diamond turns to the north, and then proceeds to say (page 218) that he experimented with 75 diamonds in presence of many witnesses, employing a number of iron bars and pieces of wire, manipulating them with the greatest care while they floated in water supported by corks; and he concludes by saying that "it never was granted to me to see the effect mentioned by Porta."

The same spirit leads Gilbert (on page 47) to regret that men are "deplorably ignorant with respect to natural things;" and the only effective way he sees to remedy this is to make them "quit the sort of learning that comes only from books, and that rests on vain arguments from probability and upon conjectures." Again (on page 82) he affirms that "men of acute intelligence, without actual knowledge of facts, and in the absence of experiment, easily slip and err."

It is evident that in his system of working, Gilbert departed from the traditions of his times. He felt that experiment must ever be the touchstone of theory. He addressed himself direct to nature, as did Roger Bacon, the Franciscan friar, centuries before him, and as Galileo was then successfully doing in Italy. The Italian *savant* aimed at overthrowing the misleading authority of Aristotle; the philosopher of Colchester frequently refutes the theorizing of the Stagirite; both were pioneers of the new philosophy. To them much more than to the author of the "Novum Organum" belongs the credit of inaugurating the inductive method of study and research. Bacon (Sir Francis, erroneously called Lord) was ignorant of mathematics and at best only an amateur in science, yet he did not hesitate to legislate, and to draw up a code of rules to be followed in scientific investigations. He even sneeringly criticises "De Magnete," saying that its author "has attempted to raise a general system upon the magnet, endeavoring to build a ship out of materials not sufficient to make the rowing pins of a boat." Yet the very work so reviled by Bacon is held universally to-day to be "one of the finest examples of inductive philosophy that has ever been presented to the world."

It may be that the English Chancellor did not find Gilbert's treatise to conform rigidly to the canons he had laid down; but Bacon's rules have never been followed by any eminent investigator; and, indeed, Draper affirms that not one important physical discovery was ever made by the Baconian instrument. Doubtless the schoolboy will continue to revere Bacon and the man of letters to praise him; but no man of science will owe allegiance to the over-estimated author of the "Advancement of Learning."

A few paragraphs upon this very relevant matter from the erudite pen of Mr. Mottelay would have been better even than the laudatory address of Edward Wright, and certainly more useful than the prolonged discussion about the various editions of "De Magnete," and the existence or non-existence of any specimen of the author's handwriting. We must say emphatically that we disapprove the biographical memoir, which is unsatisfactory, and contains at least one ridiculous blunder, that disfigures the whole of the introduction. We should strongly recommend Mr. Mottelay, in a subsequent edition, to adopt the memoir by Conrad Cooke, above referred to, and which is in all respects the best, most complete, and most painstaking of the modern (or indeed of any) published biographies of Gilbert.

In reading over the six books of this great work, one cannot fail to be struck by the variety of the author's accomplishments. He writes in Latin, and intersperses his pages with frequent Greek quotations; he is familiar with poets, historians, and philosophers, and discusses with clearness and fulness all the chemical and physical knowledge of previous ages. The work is truly monumental. It also contains Gilbert's own numerous, valuable, and costly contributions to magnetic science. First among these is his grand generalization, "the new and till now unheard of view," that the earth is a great magnet; and he is not afraid to say that this novel view "will stand as firm as aught that ever was produced in philosophy, backed by ingenious argumentation or buttressed by mathematical demonstration" (page 64).

Actuated by the searching spirit of the philosopher, he inquires into the cause of our terrestrial magnetic conditions, and he finds it to his satisfaction in the interior parts of our globe, which "possess a magnetic homogenic nature" (page 69), due in great measure to the abundant distribution in the crust of the earth of "pure native iron" and the loadstone.

To this magnetic action Gilbert attributes "the variation" (declination) of the compass. He shows it to differ with the locality, but erroneously states it (page 240) to be constant in any given place. He quaintly says: "As the needle hath ever inclined toward east or toward west, so even now does the arc of variation continue to be the same in whatever place or region, be it sea or continent; so, too, will it be for evermore unchanging, save there should be a great break up of a continent or annihilation of countries, as of the region of Atlantis, whereof Plato and ancient writers tell." After this statement, Gilbert sets to work with his "terrella" (a spherical magnet), "versorium" (bar or needle mounted on a point), and satisfies himself that he has proved the constancy of "the variation." With the same little appliances he probes the cause of this deviation, and is sure that it "is due to inequality among the earth's elevations" (page 235).

The dip, too, is known and extensively discussed. In Book IV. he describes in great detail an instrument for determining the "variation;" and in Book V. he pictures and explains an elaborate dip circle of his own invention, which very closely resembles those used at the present day. He concludes some experiments on magnetic dip with a sentence which every first year student will appreciate: "Thus may we see the level, oblique, and perpendicular positions of the needle on a terrella" (page 282).

The magnetization of iron bars by the earth's influence, and indeed all the varied phenomena of induction, are fully stated. He speaks of the field of force (*orbis virtutis*) that surrounds a magnet, and even shows how previous investigators estimated the strength of magnetized bars by using an ordinary balance. He dwells upon the first law of electrostatics, and points out how it also applies to magnets. The action of heat in weakening needles and the complete disappearance of magnetic power at a red heat, as well as the discharge of electrified bodies by flames, are all described without any ambiguity, and their causes eagerly sought after.

Gilbert devised the pivoted-needle electroscope and used it in the remarkable electrical experiments described in Book II.; he insists upon the distinction between electric and magnetic bodies, as also between magnets and magnetic substances. To him we owe such terms as electrics, magnetics, polarity, poles, equator; but nowhere do we find the abstract terms electricity or magnetism, though Dr. Lodge, in his "Pioneers of Science," page 140, says: "He it was who invented the name electricity." Gilbert's poles are "not mathematical points, but natural points," and his equator is "a natural line of demarkation between the two poles" (page 67). The pole in our hemisphere he terms North, Boreal, or Arctic, and calls the north-seeking end of his needle by the opposite names of South, Austral, or Antarctic. He is, however, wrong when, writing about the earth's magnetic axis, he says: "Just as it passed through mid-earth in the very beginning of the moving world, so to-day it tends through the center to the same points of the superficies; for but save with a vast demolition of the terrestrial mass, may these natural bounds be altered" (page 315). He likewise lapsed into error in identifying the magnetic and the geographical equator.

It is nevertheless marvelous that in a work so extensive and so suggestive, based on observation and experiment, the errors should be so few.

Gilbert was familiar with the whole literature of his subject, and it is interesting to notice how he deals with earlier writers. He admits that Thomas Aquinas, "with his godlike and perspicacious mind, would have developed many a point had he been acquainted with magnetical experiments" (page 5). Scaliger is found to be too metaphysical, using "abundant verbiage, and crowning this with many subtile observations" (page 10). Avicenna is vigorously dealt with on page 58, where we read: "But mistakenly and old-womanishly does Avicenna declare that the true antidote of this ferric poison is a drachm of loadstone taken in a draught of the juice of dog's mercury or of beet root." Lactantius is lashed on page 326 on account of his opposition to the antipodes, "for, like the most unlearned of the vulgar, or like an uncultured bumpkin, he treats with ridicule the mention of antipodes and of a round globe of earth." In reading this we must bear in mind that, unlike his contemporary and critic, Sir Francis Bacon, Gilbert was a stanch Copernican. As to the causes of magnetic movements assigned by certain philosophers, he quietly leaves them "for roaches and moths to prey upon" (page 104).

We give the above extracts to show some of Gilbert's views and his mode of treatment, and at the same time to afford an idea of Mr. Mottelay's version of "De Magnete." We must add that we have compared quite a number of chapters with the original; and though here and there we found a term and sometimes a passage which we should have endeavored to turn differently, we justly admire the fidelity and closeness of the translation. We do not pretend to say that the fidelity is verbal; we might expect that from a schoolboy, but not from a scholar. Mr. Mottelay seeks to give the meaning of his author in clear and characteristic English, and to do so he rightly permits himself the necessary latitude of amplification in dealing with the text. All the figures and diagrams of the original reappear in their peculiar, quaint form. Gilbert's singular mode of differentiating between a great discovery or experiment and a minor one, viz., by a large or a small marginal asterisk, is retained. Copious foot notes and references are added by Mr. Mottelay, which will be found very helpful. It would have been a useful feature if the original had been followed in giving at the head of each page the number of the book and chapter. The facsimiles of the title pages of various editions of "De Magnete" are reproduced at the end of the volume. They will be found to offer many points of interest. Book I. is preceded by an explanation of some technical neologisms, and the work closes with an excellent general index.

The thanks of all lovers of science are due to Mr. Mottelay for giving us in a popular form this great work of Dr. Gilbert, a work which marks the real beginning of electrical and magnetic science, and fittingly inaugurates the new era of experimental philosophy; and they are equally due to the eminent firm of New York publishers, Messrs. W. H. Wiley & Sons, who have spared no pains or expense in producing a book the sale of which, under ordinary circumstances, must have been very limited. Considerable interest in the work has, however, been created by the widely-published strictures (to use no harsher term) passed by Professor Thompson on the publishers of Mr. Mottelay's translation. We can understand the lively disappointment of

* "History of the Inductive Sciences," vol. iii., page 7.

the joint secretary of the "Gilbert Club" on hearing of the approaching publication; of his sense of mortification on knowing that the work for which a society of eminent Englishmen with very eminent secretaries had been convened to do collectively had been promptly and efficiently done by one man, and that man an American. But it is not logical to abuse the publishers (Bernard Quaritch for this country). No doubt Professor Thompson will get over his disappointment, and regret his hasty utterances. Meanwhile an admirable opportunity offers itself to the "Gilbert Club" for supplying the "long-felt want" of its subscribers by purchasing Mr. Mottelay's volume—the price of which in America at all events, is 16 s.—and delivering it in place of the "authorized version," which is now really superfluous.—*Engineering, London.*

INSTANTANEOUS PHOTOGRAPHY.

We reproduce herewith a few instantaneous photographs of horses in motion sent to us by Viscount de Ponton d'Amécourt. This skillful amateur photographer has the good fortune to have at his service an incomparable horseman, Capt. J. B. Dumas, author of "Equitation Diagonale." While the instantaneous pictures that he has taken are interesting to the photographer, they are still more so to sportsmen, for their perfection is such, as regards details, that the work of the muscles is perceived in every exertion that the horse makes. The engraver has touched up nothing in the photographs to suit us, and they are reproduced in their true size. It will be seen that the distinctness is nearly absolute (Figs. 1 and 2), despite the speed of the animal making a leap 5 feet in height, and the size of the image taken at 1-35 the natural size of the object. We add to the reproductions of the two beautiful photographs just mentioned two others that give what is called in the language of horseback riding *airs de haute ecole.* Fig. 3 shows a riding school horse, outside the pillars, making a pesade, the first phase of the cabriole. Fig. 4 gives the last phase.

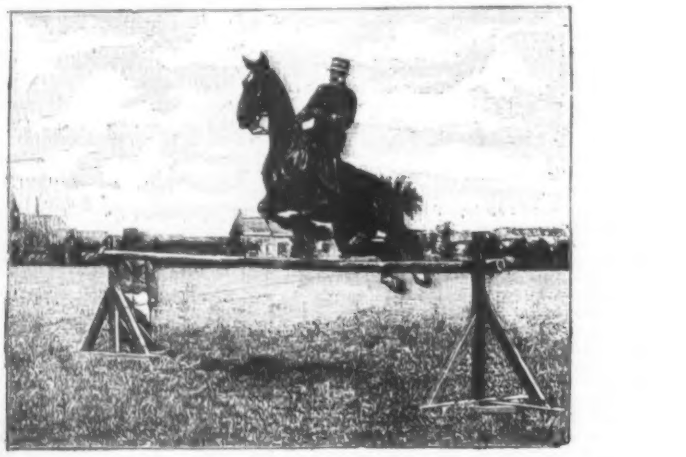


Fig. 1.—FIVE FOOT LEAP OF A HORSE WITH ITS RIDER.

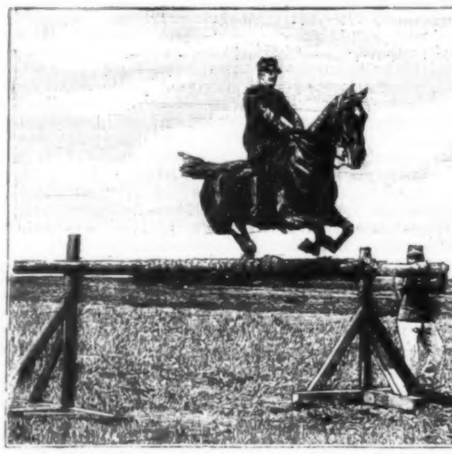


Fig. 2.—ANOTHER FIVE FOOT LEAP.

In order to obtain such results, the viscount, after trying different shutters, settled upon the one represented in Fig. 5. This apparatus is not mounted upon the objective, but is placed upon the back of the camera, immediately in front of the sensitized surface.

Fig. 3.—HORSE MAKING A PESADE, THE FIRST PHASE OF A CABRIOLE.

Fig. 4.—SECOND PHASE OF THE CABRIOLE.

It has been applied for a few years past to a hand camera of German make, and, in France, a model was presented last year to the Photographic Society under the name of "Shutter Frame." That used by the viscount is adapted to the back part of his camera, and was constructed specially for him by Mr. Bellieni, of Nancy. Before discussing the value of this apparatus, we think it well to first explain its construction. It consists of a flexible curtain impermeable to light, whose extremities are fixed to two cylinders, A and B. In the center of the curtain there is a slit, F, which is of the length of the photographic plate and of a width variable with the time of exposure desired. The cylinder, B, is actuated by a screw which is coiled up by means of a key, and the freeing of which is effected by means of the lever, D, which is actuated by a pneumatic device. A card, E, that may be maneuvered from the exterior, serves to wind the curtain upon the roller, A, and, besides, to arrest it at the end of its travel, after the slit has traversed the entire length of the plate. The power of the spring is such that without this precaution the curtain would resist but a short time and would be torn from the cylinder to which it is attached. The operation of the apparatus will be easily understood, and so we shall not dwell upon it.

In order to obtain the results that he has reached, the viscount used an objective of 10 inches focus, diaphragmed to 1/8 or 1/6, that is to say, the aperture employed was about 1 or 1½ inch. With such dimensions, shutters mounted upon the objective become very cumbersome, and their performance would, moreover, in all cases be inferior to that given by the curtain shutter just mentioned. With the latter, in fact, for every point of the plate, at the moment the slit passes, the objective always works with its full aperture. The performance is almost equal to unity, the duration of the total action of the exposure depending solely upon the length of the slit and the velocity of the curtain.

If, for example, the slit is 0·0397 inch in width and moves with a velocity of 39·7 inches per second, the exposure will be 1/1000 of a second. But it is well to give attention to one thing, and that is that this exposure of 1/1000 of a second will be applied to every band of the plate having a width of 0·0397 of an inch, and that if the plate is 3·97 inches in height, the exposure as a whole for the entire plate will have been but 1/10 of a second. Through this process we can, therefore, have every point of the image very distinct, but all the points of the same image will not have been acted upon at the same moment, that is to say, the image will be distorted.

There is no inconvenience in this in the case, for example, that occupies us, and in which the displacement of the slit of the shutter takes place with a great velocity relatively to the size of the image, such velocity being capable, moreover, of augmentation, and depending only upon the power of the spring employed. But in practice, for ordinary amateur work, often requiring less rapid exposures, we do not think it would be well to employ such an instrument, for we would then have, with very sharp negatives, distortions that would be totally unacceptable. This may be seen from the following example: Let us suppose that, with a shutter having the velocity just mentioned, we wish to photograph a boat provided with a mainmast, passing amidships in front of the apparatus, and at a distance such that the mast occupies the entire height of the plate. If the displacement of the image upon the plate takes place with a velocity equal to that which the slit has in going from the bottom to the top of the sensitized plate, that is to say, in the case that we have selected (*i. e.*, in one-tenth of a second), the bottom of the mast will be photographed in one corner of the plate and the top in the corner diagonally opposite. That will not injure the distinctness of the image, but rather its truthfulness somewhat. We here suppose an extreme case. It is clear that in practice the distinction will be much less—almost imperceptible, even, in certain cases, like those that we herewith reproduce, where the operator has skillfully calculated the size to give the image relatively to the velocity of the curtain. In our opinion, it is none the less true that it will be necessary to limit one's self to the application of this apparatus to entirely special cases, and we hope that our readers may obtain as good results as those that we give them a specimen of to-day.—*La Nature.*

FUNCTIONS OF THE RETINA.

At a recent meeting of the Physical Society, London, Mr. W. F. Stanley read a paper on "The Functions of the Retina." Referring to Young's three-nerve theory of color sensation, the author said Professor Rutherford had pointed out that there was no necessity to assume that different nerves conveyed different color sensations, for as a telephone wire would transmit almost an infinite variety of sound vibrations, so the nerves of the retina were probably equally capable of conveying all kinds of light vibrations. Professor Rutherford had further pointed out that the image of a star could not possibly cover three-nerve terminals at once, and, therefore, could not be seen as white if Young's theory was correct.

The author then described Helmholtz's experiments with a small hole in a screen illuminated by spectrum colors. For red illumination the greatest distance at which the hole could be seen sharply defined was 8 ft. and for violet 1½ ft. When the hole was covered with purple glass, or with red and violet glasses superposed, and a bright light placed behind, the eye, when accommodated for red light, saw a red spot with a violet halo round it, and when focused for violet light, saw a violet spot with circle of red. These experiments, the author thinks, show that the chromatic sense in distinct vision under critical conditions (*i. e.*, where a single nerve or a small group of nerves is concerned) depends on the colors being brought to foci at different distances behind the crystalline lens. He also infers that the same focal position in the eye cannot convey simultaneously the compound impression of widely separated colors.

Helmholtz's observations are further examined in the paper, and a series of zoetrope and color disk experiments described, which tend to show that the eye cannot follow rapid changes of color. Changes from red to violet could be followed much more quickly than from violet to red. The red impressions were, however, more permanent. The observed effects were

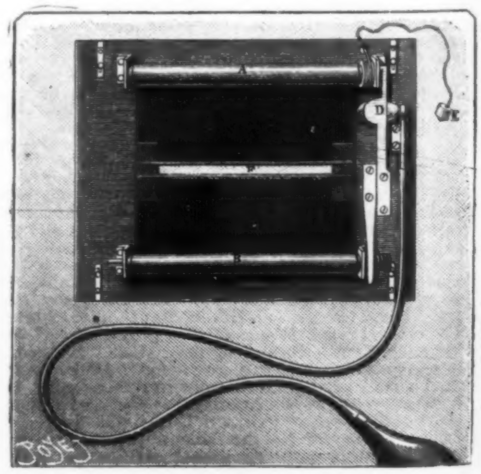


Fig. 5.—CURTAIN SHUTTER.

found to depend on the intensity of the light and also on the distance of the eye from the colored surface. Summing up his observations, the author infers that by systems of accommodation of the eye the colors of the spectrum are brought to focus on special parts or joints of the rods or cones of the retina, such focal points being equivalent, by equal depths or distances from the crystalline lens, to a focal plane formed across the whole series of nerve terminals; that all the rays of light from an object, or part of an object, of very small area and of any spectrum color, will converge to a point upon a nerve terminal, and that this terminal will be most excited by the light.

At the end of the paper Dr. Stanley Hall's views of nerve structure are examined.

Captain Abney thought the results of the zoetrope experiments were what one would have expected when pigmentary colors were used. To be conclusive, such experiments must be conducted with pure spectrum colors. The statement about the size of star images

being less than that of a nerve terminal would probably need revision. Speaking of color vision, he said the modern view was to regard light as producing chemical action in the retina, which action gave rise to the sensation of color. On the author's theory, he could not see how color blindness could be explained.

Mr. Trotter said he understood Helmholtz to have proved that nerves could distinguish quantity but not the quality of a stimulus. Since the speed at which stimulus traveled to the brain was about 30 meters a second, the wave length of a light vibration if transmitted in this way would be very small. Taking Lord Kelvin's estimate of the minimum size of molecules of matter, it followed that there must be many wave lengths in the length of a single molecule. This, he thought, hardly seemed possible.

Mr. Lovibond pointed out that the observations referred to by the author could be equally well explained on the supposition that six color sensations existed. The confusion of color he had mentioned arose from lack of light.

In proposing a vote of thanks to Mr. Stanley, the chairman said it had been shown that light could be resolved into three sensations, but it was not known how this resolution occurred.

Professor S. P. Thompson said the gist of Mr. Stanley's paper seemed to be that lights of different colors were concentrated at points situated at different depths in the retina, the violet falling on the part nearest the crystalline lens and the red furthest away. Another view of the action was that the different sensations might be due to the vibrations of longer wave length having to travel greater distances along the nerve terminals before they were completely absorbed.

THE SOUCHIER PRISM-TELEMETER.*

THIS pocket range-finder has been recently adopted in the Russian service for infantry and artillery, and is the invention of Captain Souchier, of the French army, instructor at the firing school.

The instrument consists of a pentagonal prism of glass inclosed in a celluloid case.

The five vertical faces include the following angles:

A=67°, 30′.
B=90°.
C=177°, 50′.
D=69°, 40′.
E=135°.

The prism has a height of about 0·4 of an inch, and the protecting case leaves the portions, A G and D G′, uncovered (Fig. 1).

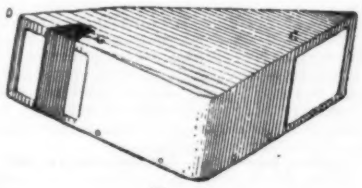


FIG. 1.

If we turn the face, A B (Fig. 2), toward an object, P, the incident rays, such as P R, which we may consider perpendicular to the face, A B, enter the prism without deviation, meet the face, A E, making with the normal at the point of incidence an angle greater than the critical angle for glass. They are therefore totally reflected on this face, and again on the face, E D, which they meet under the same conditions. The

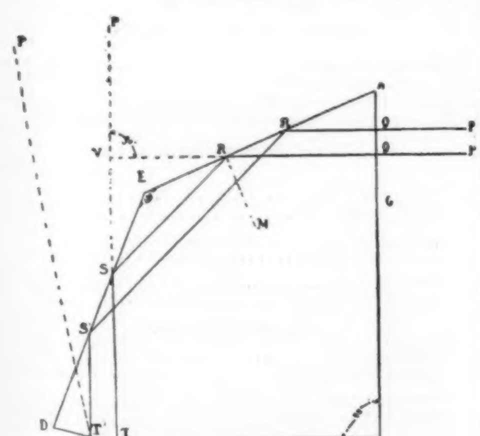


FIG. 2.

angle, A E D, being 135°, the ray after total reflection on each of the faces, A E, E D, takes a direction perpendicular to that of its incidence, P R, and leaves the prism normally to the face, B C, and consequently without refraction.

Such incident rays as P R′, which we may consider as parallel to P R on account of the distance of the object, meet the face, D C, after double reflection on the faces, A E, E D. The inclination of the face, D C, with regard to the doubly reflected rays causes them to be deviated from the normal to this face at the point of emergence, T′. The eye placed at O′ sees an image of the point, P, at P″ in such a direction that the angle, P″ O′ P, is equal to a right angle plus the angle of deviation, S T′ P″. This last angle is by the construction of the prism kept at about 1°, 05′. The operator can thus, according as he places his eye at O or O′, construct on the lines, P R′, or P R, an angle of 90°, or one of 90°+1°, 05′.

There is a position for the eye intermediate between O and O′, which permits the reflected image, P′, and the reflected and refracted image, P″, to be seen at the same time; the angle thus formed is evidently 1°, 05′. The operator can turn either the face, A B, or the faces, D C, C B, toward the object. In the first case, the deviation due to refraction is produced by the reflected ray, and in the second case by the incident ray, but the result remains the same.

This granted, let A C (Fig. 3) represent a distance which we desire to measure. The operator placed at

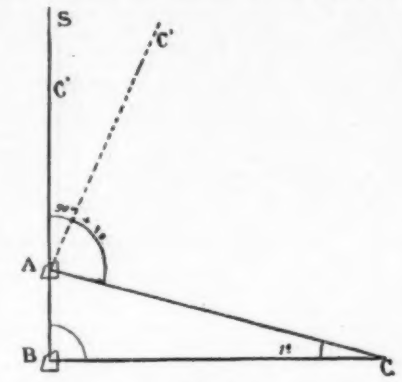


FIG. 3.

A constructs the angle, C A S, of 90+1°, 05′, by marking with a signal, S, the direction, A C′, in which he sees the left hand image of the point, C. He then moves back along the line, A S, to some point, B, where the right hand image, C″, of the point, C, coincides with the signal, S. The angle, C B S, is 90°.

The angle at C is equal to the difference between the angles, S A C and S B C, that is to 1°, 05′. Now the sine of the angle 1°, 05′ is sensibly equal to 1/50; and in the triangle, A B C, we have $AC = \frac{AB}{\sin C} = 50 \times AB$.

We have simply to measure the base, A B, and multiply it by 50 to determine the distance, A C, sought. Generally the sine of the angle formed by the two

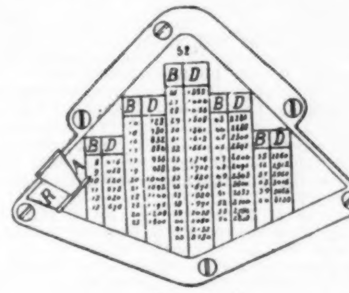


FIG. 4.

images is not exactly 1/50, on account of difficulties in the construction of the instrument. We must then multiply the base by some other number than 50. In order to avoid this multiplication, the maker has placed upon the back of each instrument a table which gives in meters the distances corresponding to each base ordinarily occurring in practice. The table is arranged in two columns of B, bases, and D, distances. Distances corresponding to bases outside the limits of the table, either way, are obtained by multiplication or division. Thus the distance corresponding to 10 meters is half of that for 20 meters, and the one for 80 meters is twice that for 40.

The instrument is usually held in the left hand between the thumb and first three fingers, the fingers being bent so that the operator can see under them. The

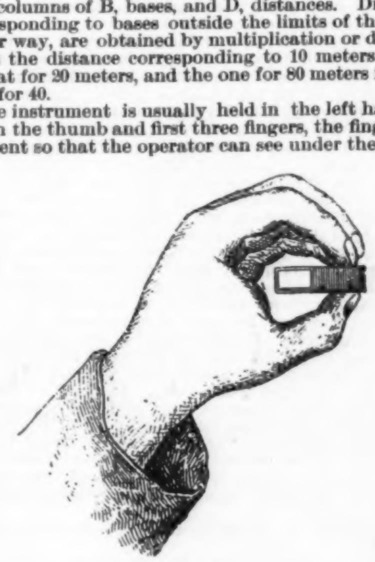


FIG. 5.

base may be measured toward the signal, S, or away from it by moving certain slides which cut off the rays corresponding to 90° or 90 + 1°,05′, depending on which angle is used first. The distant object is in this case on the right hand and is always perpendicular in direction to the base measured.

Should the ground prove impracticable for measuring in the above direction, then by taking the instrument in the right hand, facing about so as to bring the object on the left hand, and turning the instrument round so as to bring the side, A B, to the eye, the operator can measure the base in the opposite direction.

The mean error is given as about 25 meters per thousand meters.

Captain Eroguine, of the Russian service, has added to the telemeter an attachment of his own invention by which the instrument can be applied to a field glass.

This attachment consists of a cap, M, which is placed over one of the object glasses of the field glass and is kept in place by the elasticity of four clips (a).

A horizontal opening is cut in the lower part of this cap into which the telemeter fits either on the side DG′ or AG. Two projections (b) on this cap, each car-

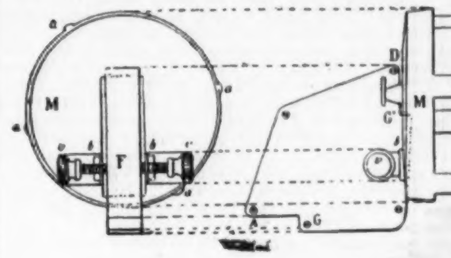


FIG. 6.

rying a screw (v), hold the range finder in place.* The opening, F, is wider than the thickness of the prism and the resulting aperture permits the object to be seen outside the instrument. By tightening one screw and loosening the other, this aperture may be made at either the upper or lower base of the telemeter.

From experiments made at the firing school it was shown that by using the field glass, distances of from 5,000 to 8,000 meters could be measured, thus rendering the range finder suitable for artillery purposes. At a distance of 2,000 or 3,000 meters this combination gave a precision twice as great as when the prism was used alone, and the time taken was but little longer.

MIRROR-WRITING.†

By W. W. IRELAND, M.D., Scotland.

BUCHWALD and Erlenmeyer‡ have directed attention to what they call spiegelschrift, or mirror-writing, because, like the impression of a letter taken upon blotting paper, it can be most easily read by those not used to it in a mirror, where the reflected image takes the appearance of ordinary writing. This inversion of our written characters is sometimes done as a species of puzzle for amusement or curiosity; but I have met with several instances where it was seriously produced apparently as an imitation of ordinary writing.

E. M. was an imbecile girl, paralyzed on the right side from birth or early infancy. She came under my care when seven years of age, and was subject to occasional attacks of epilepsy or epileptic vertigo. She was active in disposition, mirthful and somewhat mischievous. When she was about eleven years of age, on the governess commencing to teach her to write, which was done by getting her to copy a lithographed line at the top of the page, the girl formed the letters with the left hand from right to left in mirror-writing.

L. N., aged fourteen, a genetous imbecile girl of considerably greater intelligence than the first case, was left handed. She began to write in mirror-writing with her left hand, but was interdicted, and in a few months gave it entirely up. She was gradually broken from using the left hand, and could sew pretty well with the right. When I asked her to give me a specimen of the mirror-writing, she could only do it with her left hand. Apparently she can write from right to left with about as much ease as from left to right, but cannot now read it so well. Though she speaks freely on simple subjects, she cannot make any explanation as to the directions which she gives to her writing with either hand; but one cannot expect any analysis of a mental process or complex action from an imbecile girl.

There were two idiot boys in the school who formed pot hooks from right to left, being left handed, so that in time they would teach themselves mirror-writing. I wrote to several superintendents of training schools for idiots, but none could give me any information on the subject save Mr. Millard, Superintendent of the Eastern Counties Asylum, at Colchester, who sent the description of an imbecile boy about twelve who "wrote backward with his left hand, so that it is only legible by turning the paper round or by a mirror." Since my paper in *Brain* appeared, I have found that mirror-writing is not uncommon among left handed children in schools for imbeciles, but that the teachers who were anxious to break the patients from writing with their left hands paid no attention to it, regarding it simply as a bad custom.

A friend of mine who had seen the mirror-writing of the imbecile girl was struck at finding the same inversion in one of his own pupils. He was left handed, and as teachers think it their duty to compel left handed children to use their right, the boy finding this difficult, when the teacher was not looking secretly wrote with his left hand. The result was a page of mirror-writing, which the boy apparently thought was a copy of the lithograph.

He was a thin and pale boy of thirteen, who out of school used the left hand. The teacher described him as rather intelligent, and getting on well with his lessons. On being requested to copy a passage out of a book in mirror-writing, he soon returned with it fairly copied. I asked him, "Did you write this with your

* From the *Revue du Cercle Militaire*, by Lieut. J. C. Bush.—*Jour. Mil. Ser. Inst.*

* A full discussion of this range finder will be found in the *Revue d'Artillerie*, January number, 1893.

† A chapter from "The Blot upon the Brain." Illustration omitted. This chapter is given here to call attention to this chirographic phenomenon in a peculiar class of cases such as Dr. Ireland is especially familiar with.—*Alienist and Neurologist.*

‡ "Die Schrift, Grundzuge ihrer Physiologie und Pathologie," Von Dr. Albrecht Erlenmeyer. Stuttgart, 1879.

See also "On Mirror-Writing and its Relation to Left-Handedness and Cerebral Disease," by William W. Ireland. *Brain*, vol. iv., page 361.

"Peretti ueber Spiegelschrift," *Berliner Klinische Wochenschrift*, 31 Juli, 1883.

"Changes in Handwriting in Relation to Pathology," by A. Bianchi, M. D., translated by Joseph Workman, M.D. *The Alienist and Neurologist*, October, 1883. Dr. Samuel Wilks seems to be the first living pathologist who refers to Mirror-Writing. See his "Notes on the History of the Physiology of the Nervous System." *Guy's Hospital Reports*, vol. xxiv.

right or your left hand?" At which he said with some hesitation, that he did it with his right. I told him nobody would be angry with him; when he confessed that he had written it with his left hand, as we had asked him for a specimen of the writing, and he could only do it with the left hand. He could read the mirror-writing fluently. It is perplexing that any one should in copying a line lithographed at the top of the page imagine he was correctly reproducing it when he was writing it in an inverse direction. For example, if any one were told that he must write the word "wonderful" from right to left, he would commence with the l, and trace the letters backward; while these two pupils not only wrote from right to left, but they inverted the image of the word, so that while the w of the copy was on the left, in their imitation it appeared on the right, as if they had scratched on a pane of glass, and turned it and read it on the opposite side. This, of course, is different from ordinary handwriting from left to right, such as was practiced by the Hebrews and Etruscans, and in the modern Arabic letters throughout the Mohammedan world. In their manuscripts or lithographs the lines begin at the free side of the page and run to the left; but then the Arabic letters are naturally adapted to be traced in this way, and indeed it would be difficult to form them in any other. Familiar with this writing by my residence in India, I am of opinion that if it is more difficult to read than the English characters, this is not because it runs from right to left, but owing to the suppression or uncertain quantity of vowels, the writing is so little phonetic that it needs a knowledge of the language ere one can read a Hindustani or Arabic book. A clerk cannot copy Arabic writing so quickly as English, but this is owing to the nature of the characters, which are more numerous, most of them having an initial, medial and final form.

I have been told by one who practiced mirror-writing for amusement that it is easier to trace with the left hand; and the following experiment made by my friend the teacher will show that there is a physiological tendency in the left-handed children to fall into mirror-writing. He took a class of sixty boys and girls, and told them to write their names with their left hands. All copied as well as they could, writing from left to right. Some two girls and three boys wrote in mirror-writing. These were found to be all left-handed, and the only left-handed in the sixty. It did not appear that these children were conscious that they were writing in an inverse direction different from the rest. The left-handed children went to work instantly without any perplexity and traced their letters better than the other children.

Miss C., the teacher in a public school, took 134 children of the junior division, and, getting the assistance of a colleague, separated them into small divisions, gave them pencil and paper, and told them to write with their left hands, and not to look on one another's papers. Apparently there were six children known to be left-handed, or to have a tendency to use the left hand, and three of them wrote in mirror-writing, and none else.

Dr. Peretti has made similar experiments on a number of school children in Germany. He found that out of 200 pupils, between seven and twelve years of age, 11 wrote both words and ciphers entirely in mirror-writing; besides this, 8 wrote all the ciphers, and 31 some of the ciphers in this form. Thus 50 children (= 25 per cent.) used mirror-writing in whole or in part. He found that of these 200 children 25 were left-handed; and of the 50 who used mirror-writing 12 were left-handed (= 24 per cent.); but of those who wrote normally only 8·6 per cent. were left-handed. From Peretti's own experiments, as well as those of Rüthe, it seems that ciphers are more frequently traced in mirror-writing than ordinary text. In the experiments recorded by me all the children who unconsciously used mirror-writing were left-handed. The youngest children in the school were selected, and their average ages would no doubt be lower than those examined by Dr. Peretti. He correctly remarks that young children and uneducated persons are more apt to fall into mirror-writing.

In one experiment it was found that a man (a Scotchman who had lived in India), who tried to write a few Hindustani words in Arabic characters with his left hand, unconsciously traced the letters from the left in mirror-writing. Peretti tells us that the Japanese, whose native characters run from right to left, when asked to write with the left hand do so from left to right.

Dr. Erlenmeyer, in his interesting pamphlet on the physiology and pathology of writing, observes that it seems to be easier to use the arms in a centrifugal direction, the left from the right and the right from the left, the motions not being hindered by the trunk of the body; and that where ease, elegance and security are needed, the movements of abduction are always performed. He gives turning a handmill, striking a lucifer match, and executing the most brilliant passages on a piano as examples, and assures us that he could easily give more of the kind. In that case his instances do not seem well chosen. I have been assured that many of the most striking passages on the piano are performed both to and from the center, and some exercises requiring skillful execution are certainly done in a centripetal manner; using the sling, bowling and batting in cricket are examples; and, in fact, whether in fencing, swimming, sewing, or other actions, movements must be made both from and toward the center of the body. Nevertheless, taking everything into consideration, it appears true that most actions requiring skill in their performance are done easiest by the arm in a centrifugal direction.

Dr. Wilbur, of Syracuse, N. Y., has kindly sent me specimens of the performance of a man who could write the same words with both hands at once, the right hand in the usual way, the left in the mirror-writing; but as he could also do the same feat with both hands moving from left to right in ordinary text, it seemed to be more of a sleight-of-hand than any obedience to a physiological tendency. Dr. Wilbur mentions the case of a left-handed child who, when beginning to read, asked his father what "efiw" was. On being told that there was no such word, the child brought his book and pointed to the word "wife." The boy for some time after made similar mistakes. Such inversions not unfrequently occur in teaching imbecile children to read; they will call "no" "on," or "was" "saw." We generally teach them small words before teaching them the letters.

Buchwald, in the Berlin *Klinische Wochenschrift*, gave the case of a man of forty-five, who presented the ordinary symptoms of apoplexy, with paralysis of the right side. After the somnolence, which for some days followed the attack, had disappeared, it was found that he was aphasic, and to enable him to communicate his ideas, he was induced to try writing with the left hand, as he could not do it with the right. He wrote in a very skillful manner his name in mirror-writing from right to left, as well as the numerals from 1 to 10, except the figure 8, which he had forgotten. The inverse direction of his writing was pointed out to him, but he could not be induced to try writing from left to right. His name and some figures being written out and held before him, he copied them awkwardly, but again fell into mirror-writing. After a time he traced the numbers 1, 2, 4, 6, 8 and 9 correctly, but gave 3, 5 and 7 in mirror-writing. He was asked to multiply a few figures, and the ciphers were correctly put down for him; he wrote the sum from right to left. In this case he must have multiplied the numbers in his mind and then recorded the result in mirror-writing. The patient remained about six months in the hospital at Berlin, during which time, though the power of speaking, writing and reading returned, the tendency to mirror-writing still persisted. He gave himself great trouble in trying to copy writing from left to right; he said that he could not perform it in this direction with the left hand; when he again had the use of the right hand he would do it correctly. In trying to trace the letters from left to right, he was obliged to use the half-paralyzed right hand to help the left, otherwise the operation miscarried. The 5 was the most difficult to form. Even with the right hand he traced the cipher in mirror-writing, at least he could not manage the hook of the 5 otherwise.

The best known example of a change from right-handed to left-handed writing, Dr. Erlenmeyer tells us, is that of the MS. of the "Codex Atlanticus" of Leonardo da Vinci, in the Amboise Library at Milan. It was generally said that in adopting this singular style of writing, Leonardo wished to preserve his work from the eyes of superficial readers; but we can now give another explanation. There is a diary in the National Library at Naples of the priest, Antoine de Beatis, who, in 1517, traveled in the train of the Cardinal of Arragon, through Germany, the Netherlands and France. The cardinal visited Leonardo da Vinci, who passed the last years of his life in the neighborhood of Amboise, in a villa given to him by Francis I. De Beatis remarked of the famous artist in his journal, that "nothing more of value in painting could be expected of him, as he had paralysis of the right hand." It would appear from this that Leonardo da Vinci, being unable to use his right hand, wrote with his left, and fell into the practice of writing from right to left, in obedience to a tendency which we have sought to illustrate. A little reflection will enable one to perceive that mirror-writing with the left hand is the exact counterpart of ordinary writing with the right hand. There is the same action from the center of the body outward, and the same muscles are used in each limb in the same directions, just as in the action of swimming; so we have only to suppose that in mirror-writing with the left hand, the writer obeyed the acquired tendency to a given muscular adjustment. But in some of our instances, children unconsciously produce mirror-writing as a correct copy of ordinary writing, from which it may be concluded that the image in their minds from which they wrote was also inverted.

It may be asked, is the image or impression, or change in the brain tissue, from which the image is formed in the mind of the mirror writer, reversed like the negative of a photograph? or, if a double image be formed in the visual center, one in the right hemisphere of the brain and the other in the left, do the images lie to each other in opposite directions—*e. g.*, C on the right side and Ↄ on the left side?

Dr. Peretti believes that the tendency to use mirror-writing in hemiplegia of the right side is owing to the mental obtuseness of the patient rendering him like a young child, or an uneducated person, in whom the mental image of the characters is not so firmly fixed. He quotes the observations of Heidenhain and Grutzner, that a woman hypnotized on the left side of the body—which, it is assumed, implicates the right hemisphere—traced mirror-writing with the right hand as long as she was left alone, but in the usual way when expressly directed to do so. When hypnotized on the right side of the body, she wrote to the right. I cannot account for this on my hypothesis, nor indeed on any other, save by assuming that the woman had heard something about mirror-writing in palsy before she was hypnotized without correctly understanding it. Dr. Elliotson thought he had demonstrated the baseless localizations of phrenology by exciting emotions or actions corresponding to different parts touched upon the head of his mesmerized patient, who must have deceived him some way. In fact, as Dr. Peretti admits, the phenomena in persons hypnotized in one side are somewhat perplexing, since in Heidenhain's and Grutzner's experiments as many persons were found to be affected with aphasia through the right side of the brain being acted on as through the left, which is difficult to square with direct pathological observation.

Dr. Bianchi, of Naples, is more favorable to my hypothesis.

The child, he observed, attentively fixes the model, in order to impress the image on his brain, and to constrain the muscles of his hand to follow the given direction; sometimes, instead, he does no more than pass with the ink over lines (letters) traced in pale color on the paper, and thus he obtains that the unconscious impression of the motions executed by the hand is imprinted on the brain along with the image given by the sight; and by many times repeating the same impressions of images and muscular motions associated with the image, it happens at length that they obtain such close association that, in the adult, it is impossible to distinguish the two phases of the phenomenon. But the same impressions are always produced, and their imprint is preserved in the memory, becoming finally so profound that the practiced man succeeds in writing with the eyes shut, as well as with them open, presenting at such times only some disorder in the distribution of the words in the horizontal lines and the punctuation. Experiment, therefore, tells us that, for the act of writing, we require the impression of the image of the words, and further, the impression of the motions necessary for their formation. This last fact seems to have its seat in the left hemisphere prevalently, but a little in the right also, for it cannot be admitted that the binocular impression transmitted from the eyes, and producing equal images on the hemispheres, calls forth only on the left the muscular contractions necessary for the external impression of the image.

In a hemiplegia of the right side it will therefore happen that the image, not calling forth, on the left hemisphere, any centrifugal motion of the muscles of the right hand, will oblige the extensor cellular groups in the sound right hemisphere to write from the left, because of the preserved remembrance of the muscular combination associated with the image of the word. Hence there will be an identical centrifugal motion, and the reversed lithographic writing.

THE ORIGIN OF COLOR.

RELATION OF MOLECULAR AND ATOMIC VOLUME TO COLOR.

By William Ackroyd, F.I.C., Public Analyst for Halifax.

In the presence of an influx of new and old ideas regarding the origin of color, I may be permitted to point out that some eighteen years ago I constructed a metachromatic scale, a generalization resulting from the study of color-changing bodies, and I applied the scale to the study of color in compounds, arriving at a law of color for binary compounds (*Chem. News*, xxxiv., p. 76, and *Phil. Mag.*, December, 1876). In discussing the cause of these phenomena, I initiated the idea of "potentiality." The year after I published a method of making, and the measurements made of the molecular aggregates concerned in these structural absorption phenomena (*Chem. News*, xxxvi., p. 159).

In 1884 Carnelley, using the metachromatic scale I had devised, and surveying the subject from the more comprehensive vantage ground of the periodic law of the elements, showed that there are indications that the color of compounds is a periodic function of the atomic weight (*Phil. Mag.*, August, 1884). In the early part of 1892 I communicated to the Physical Society of London what I take to be the law of color and constitution in a paper which is not yet published. The law may by thus briefly stated: In a series of molecules with a constant radical R, and a weight variable radical R′, the color varies in a definite order, increase of weight of the variable radical R′ causing change of color toward the black end of the color scale (see below). In support examples were given in which R′ was an electro-negative element; elements belonging to a natural series like Mg, Zn, Cd, and Mg, combined with a common simple or compound radical; water in crystalline salts; an organic radical like NH_3, or a metal in an isomorphous group.

The following argument has occurred to me, which may be taken as a further contribution to this interesting subject. A color-changing body has its temperature gradually raised and its color altered in the order of the metachromatic scale; during this change its specific gravity is decreasing, and we may assume that inversely its molecular volume is increasing. Hence we may correlate the change of color from white through the scale to black with increase of molecular volume, thus:

White, blue, green, yellow, orange, red, brown, black.

Increase of molecular volume.

A similar difference of molecular volume in comparable compounds exhibiting conformity with the laws of color referred to in the first paragraph is apparent in the following examples which I have calculated:

Pairs of Binary Compounds.

	Molecular Volume.
HgO, red	19·5
Hg_2O, black	43·4
Bi_2O_3, yellow	56·7
Bi_2O_5, brown	84·1
Sb_2O_3, white	49·9
Sb_2O_5, yellow	49·1

Crystallized Salts.

$CuSO_4$, white	44·0
$CuSO_4,5H_2O$, blue	113·0
$PtCl_2$, green	45·3
$PtCl_4,8H_2O$, yellow	196·7

A Natural or Periodic Series of Compounds.

MgO, white	11·8
ZnO, white to yellow	14·8
CdO, red to brown	15·6
HgO, red	19·5
ZnS, white	24·8
CdS, yellow	31·9
HgS, white to black	30·0

An Isomorphous Group of Oxides.

Al_2O_3, white	25·0
Cr_2O_3, green	30·3
Fe_2O_3, yellowish red	30·3

The colored non-metallic elements also exhibit the same relations of color to atomic volume, thus:

	Atomic Volume.
Sulphur, yellow	31·2
Selenium, red	37·2
Chlorine, green, liquid	53·3
Bromine, red, liquid	53·9
Iodine, dark red, liquid	56·3

Carbon in its different forms conforms to the same law.

These examples from compounds and elements comparable among themselves therefore demonstrate a new

law, viz., *that increase of absorption of light in the order of the metachromatic scale is accompanied by increase of molecular and atomic volume.*

At the present stage of the inquiry it is difficult to say what are real exceptions to this law on account of the uncertainty in some cases as to what may be the molecular weight of compounds which cannot be vaporized; thus cupric oxide with the formula CuO would be an exception when compared with cuprous oxide, Cu_2O. Is the formula of cupric oxide, however, CuO or xCuO? If we take it as Cu_2O_2, *e. g.*, it conforms to the law.

Halifax, January 12, 1893. —*Chem. News.*

LATENT HEAT.

ACCORDING to certain eminent authorities in ethics, there can be no progress in the absence of skepticism. So long as men believe what they are told to believe, there can be no advance made on the past. It is easily seen, however, by most thinkers, that if this theory were pushed to its limits, we should sacrifice all the teaching of experience. We should reject as untrue the accumulated learning of past generations. Every physicist would have to start afresh to toil in the field of science, and satisfy himself by the work of his own hands that a stone dropped from a height will fall 16 ft. 1 in. in a second; that water boils at 212°; that hydrogen gas is given off when dilute sulphuric acid acts upon zinc; that ammonia dissolves copper; that air becomes hot when it is compressed, and so on. Life, however, is too short for work of this kind, and so however skeptical a man may be in theory, in practice he is satisfied to take a great deal upon trust. There are, however, exceptions to this rule, and Mr. Donaldson is one of them. Mr. Donaldson is a master of arts of Cambridge University, and a high wrangler. His attainments lend a certain weight and importance to his utterances, which would not pertain to a man less educated or skilled in the use of mathematical tools. He will pardon us then if we say that we publish the letter which will be found on another page, not because it has been written by Mr. Donaldson, but because the fact that it has been written by a master of arts and a wrangler imparts to it a species of vicarious importance which it does not otherwise possess. The personality of the writer is merged in his university honors. Mr. Donaldson has played the part of scientific skeptic for many years. Who does not remember his book on the "Principles of Construction and Efficiency of Water Wheels," published in 1876, in which casting to the winds the teaching of the Lowell experiments, and the elaborate investigations of Rankine and Thomson, he wrote as follows: "The coefficient of efficiency of turbines is usually stated to be equal to that of high breast wheels, or about 0·75. The investigations of the author have led him to the conclusion that the efficiency cannot much exceed 0·5. The argument of those who uphold the higher coefficient is simply this: The power lost by the water must have been communicated to the machine; if not, what has become of it? If such an argument be applicable to the case of one hydraulic machine, it must be applicable to all. Thus the water in the tail race of an undershot wheel with flat vanes moving at its best velocity moves with only half the original velocity, 75 per cent. of the original power of the current has been lost. Therefore 0·75 is the coefficient of efficiency of undershot wheels."

Mr. Donaldson now pushes his skepticism into the regions of heat and steam. He holds that low-pressure steam, used without expansion, is more economical than high-pressure steam, used with expansion; that jackets are a source of loss, and asserts to all intents and purposes that the teachings of those who have made thermo-dynamics a special study, such as Regnault, Joule, Thomson, Rankine, Clausius, Fairbairn, and Clerk Maxwell, are erroneous. To those who, like ourselves, are unable to believe that the men we have named were incompetent as investigators, or mendacious as writers, Mr. Donaldson will appear as the solitary exponent of a rank heresy. But it is always good for the world to hear what an eminent heretic has to say, and after all it may turn out perhaps that our correspondent's opinions are based on an unfortunate misunderstanding. There is, however, room, we fear, to believe that his want of faith goes deeper than this, and that he disputes not only the deductions which they have drawn from experiments, but the propriety of the experiments themselves. With this latter point it is, of course, impossible for us to deal. Concerning the possible misunderstanding, however, it may be worth while to say a few words.

Mr. Donaldson does not believe in latent heat. In other words, he will not have it that about five times as much heat is needed to boil away a pint of water as will suffice to raise it from 32° to 212°. His incredulity is akin to that which he imputes to the believers in turbines with an efficiency of 0·75 per cent. He cannot understand what has become of the heat which cannot be appreciated by a thermometer. Something of his error is no doubt due to the use of the inadequate term "latent heat," which implies, no doubt, and is very generally taken to mean, that the heat is all there, only it is somehow hidden or concealed. We quite agree with Mr. Donaldson that there is no more heat in the steam than there is in the water, but our acquiescence in his views stops at that point. After the boiling point has been reached, the further heat added by the lamp of the laboratory or the furnaces of a steamship is converted into work. It is expended in bringing about changes of state. Mr. Donaldson's skepticism, then, narrows itself to this, that he does not believe that 965 units of heat are required to convert into steam 1 lb. of water at 212°. Far be it from us to undertake the task which the writings of such men as Regnault have failed to accomplish. But we may, nevertheless, call his attention to the fact that water is in no sense or way peculiar in demanding the expenditure of heat to effect a change in its state. The same thing holds good of every known substance solid or liquid, and would hold good of a perfect gas no doubt only that for it a change of state in the ascending scale is, so far as is known, impossible. And this we say, although it is not impossible that a gas submitted to an enormously high temperature—as, for example, in the sun—may assume yet another state concerning which we have in this world no experimental knowledge whatever, unless, indeed, some abnormal results obtained by the spectroscope admit of explanation on this hypothesis. Such questions, however, and those raised by Mr. Crookes in connection with extremely high vacua have nothing to do with the issues raised by Mr. Donaldson. As an illustration of how heat becomes converted into work, and disappears in the process, we cannot cite anything better than the melting of ice. To melt a pound of ice, beginning the process with the ice at 32°, requires as much heat as will suffice to heat 143 lb. of water from 39° to 40°. The molecules of the ice are bound together by a very great force. How great is proved by the all but irresistible effort to dilate exerted by water in the act of freezing. The molecules are compelled to assume a definite relation to each other. That is to say they form crystals, and the force which they exert in compliance with the law is, no doubt, the equivalent to a large extent of that which is required to drive them apart again. Consequently, to melt one pound of ice requires $143 \times 772 = 109{,}396$ foot pounds. It would suffice to lift the ice to a height of over twenty miles. It represents over 3 horse power exerted for one minute. Beyond all question, this heat has actually disappeared; it has been wholly consumed in producing change of state, and the water at 32° is now competent to reconvert—by resuming the condition of ice—into heat all that has been expended on it. The disappearance of heat in this way is not peculiar to ice. The melting of a pound of sodium nitrate converts 113 units of heat into work. The converted heat of a pound of beeswax is 175 units, and so on. If we take water at 32°, and apply heat, we shall find its temperature rise, simply because no change of state is effected, and the heat remains as heat, and can be measured by a thermometer. But as soon as the point is reached at which, under the limiting conditions of pressure, change of state can begin, the thermometer will no longer rise. This point is attained under ordinary normal atmospheric conditions at 212°; subsequently ebullition commences. Heat is being converted into work, the work consisting in overcoming the molecular adhesion of the water, and imparting motion to the molecules. In doing this very nearly 966 units are converted, so that the total quantity of heat required to turn into steam one pound of water beginning at 32° is 1,147 units. The 966 units are as completely lost as heat as are the 43 units converted into work per horse power per minute in a steam engine. If, however, the steam is not permitted to do any external work, it will, on being converted back again into water, restore the whole of the heat expended upon it in the first instance.

It will be seen that Mr. Donaldson cannot rest content with tilting against the theory of the latent heat of steam: he has a much larger part to play. He will have to show that all those who have previously dealt with the matter are in error in assuming that a change of state can be produced without the conversion of any considerable quantity of heat into work. With one word of caution to our readers we leave the subject. Mr. Donaldson has a good deal to say about specific heat. It must not be forgotten that the term is purely one of comparison. The standard, water, is an arbitrary standard, adopted because more heat is required to raise water through any given range of temperature than any other known substance; consequently the specific heat of all other bodies can be expressed in fractions of unity. "The absolute specific heat of water" is sometimes spoken of with a certain regret as an unknown quantity. But it is by no means easy to see what the phrase is intended to mean. We might as well speak of an absolute foot or an absolute pound. We dare to hope that Mr. Donaldson has unwittingly attached a meaning to certain terms which they are not intended to convey. In any case his letter is an instructive example of what the skeptical principle can do when pushed to its limits by a man skilled in the use of mathematical tools and appliances.—*The Engineer.*

VARIATIONS OF GRAVITY.

By M. MASCART.

I HAVE on former occasions used under the name of a *gravity barometer* an instrument by which the variation of gravity between different stations may be determined. The apparatus has the drawback of being very fragile, but the same arrangement has great advantages in examining whether there are temporary variations in one and the same place.

For some years past I have arranged a barometric tube containing a column of mercury four meters and a half in length, which counterbalances the pressure of a mass of hydrogen contained in a lateral vessel. The whole apparatus is sunk in the ground with the exception of a short column of mercury at the top. The level of the liquid is compared with a lateral division, the image of which is formed in the axis of the tube, and the points may be fixed to within the $\frac{1}{100}$ of a millimeter.

Direct observations at different times of day only showed a continuous course, the greater part of which was due to inevitable changes of temperature; certain results can only be obtained by photographic registration.

In the proofs submitted the differences of level are multiplied by 20; they correspond to the variations which are directly observed on a column 90 meters in length.

The curves ordinarily present a very regular and slow course, which is especially due to changes of temperature; but for some days sudden accidents are seen, the duration of which is from fifteen minutes to an hour, and which do not seem to be explicable otherwise than by correlated variations of gravity. These accidents may attain and even exceed $\frac{1}{20}$ of a millimeter, which corresponds to $\frac{1}{86400}$ or one second per day, supposing that they lasted the whole day.

In order to have a term of comparison, it is sufficient to observe that if the difference between high and low water is 10 meters, the liquid layer would produce a variation of $\frac{1}{500000}$ of the level value of gravity, that is one-fifth of the preceding.

The existence of these temporary variations of gravity appears undoubted and deserves attention. I intend to organize at the Observatory of the Parc Saint Maur an apparatus constructed with more care, from which all casual trepidation of the ground is excluded, and the indications of which can be continuously followed.

Observations of this kind will no doubt present a peculiar interest in volcanic districts if the changes are due to displacements of masses in the interior.—*Comptes Rendus, Jan. 30, 1893; Phil. Mag., March, 1893.*

PRECAUTIONS AGAINST CHOLERA.

How tenderly, minutely and wisely, says the *Therapeutic Gazette*, the paternal German government advised its children during the recent cholera epidemic may be seen from the following rules for avoiding the pestilence, issued by the Imperial Bureau of Health, which are published in the *Therapeutische Monatshefte*, September, 1892:

1. Keep your presence of mind in the danger; avoid too great anxiety, for it clouds your clear judgment. Only the man who thinks clearly can make proper use of the precautions against danger.

Maintain cleanliness in your person and surroundings. Discretion, temperance, precise cleanliness, prove the best protection against disease.

Hold firmly to your ordinary, regular mode of life. Avoid festivities and assemblages of people.

Avoid medicines as long as you are well.

Visit the sick only when your duty calls you.

Avoid intercourse and close contact with persons who come from cholera regions.

Do not leave your home in order to escape the disease. Consider that you may be in greater danger in traveling, and living under altered conditions in a strange place, than while leading a careful, regular life at home.

2. Do not put other objects besides food and drink in your mouth, *e. g.*, the fingers in turning through a book, pen holders, lead pencils, etc.

Drink as little water as possible, and only such as you know to be above suspicion.

Pure spring water is, as a rule, unsuspicious. Water from deep pipe wells and from closed pipes, if taken from open waters, such as have been subjected to a genuine filtering, is safe. (Small house filters, unless frequently changed or cleaned, are rather harmful than useful.)

Water from rivers, ditches, ponds, flat, open or poorly covered springs, also from springs which are near dirt or dung sites, is suspicious during cholera epidemics. All washing and rinsing, as well as pouring out of dirty water near springs, may be dangerous to health.

Suspicious water during the prevalence of, or near, cholera, is only safe to use for drinking, washing the face, rinsing the mouth, washing utensils used for food and drink and the like, after being boiled one minute. The germs of the disease are destroyed by cooking, but fresh germs may again occupy it if it stands long.

To make boiled water taste well, add to each glass (half a pint) as much tartaric acid as you can take on a knife point, or two drops of hydrochloric acid.

Keep water in clean vessels.

Tea, coffee and cocoa are permitted drinks, also good beer and pure wine.

Beware of ice and very cold drinks.

Let your beer be clear and fresh, neither sour nor insipid; have it served to you in glasses which have been washed with unsuspicious water (when necessary, boiled).

Bitter schnapps often contain aloes, hence act laxatively and are questionable.

Mineral waters are unquestionable, if they come from natural springs or are prepared with distilled water.

Avoid drinking uncooked milk.

The disease may adhere to butter and fresh cheese, if they were prepared or kept near persons ill with cholera.

Eat fruit and vegetables, also onions and the like, only in a cooked state.

Eat nothing uncooked or unroasted which strange hands have touched, unless you know them to be reliable.

Purchase food only from reliable, clean shops. Avoid such as are in cholera houses.

Avoid all excess in eating and drinking. Be especially cautious if you incline to diarrhœa.

Eat and drink nothing as wholesome which is in a sick room. Consider that flies and such insects might carry the germs of disease from the patient to your food.

Even cigars may convey infection in a patient's house.

3. Keep your head cool, your body warm, your feet dry.

Live and sleep in pure air; fumigations do not prevent contagion.

Wash your hands frequently during the day with water, soap and brush, especially before you touch eatables.

If you have touched any dirty or suspicious objects, first wash your hands carefully with a solution of four teaspoonfuls of water-clear, fluid carbolic acid in a quart of water (five per cent. carbolic acid solution); then wash this off with clean water and soap.

In cholera regions do not bathe in rivers or ponds.

Use a public privy only in case of necessity. The seats of privies which are used by strangers should be cleaned daily with soapy water. For this take one pound of soap to a pail of hot water. If your privy is used by persons suspected of disease, rinse the wall of the funnel with freshly slaked lime (1 part quicklime to 4 parts water).

4. The infectious material of cholera is contained in the excretions of the patient. It adheres to soiled linen and clothing, and can be transmitted by anything which touches such objects or excretions, even when this only occurs indirectly and not in a noticeable manner.

Excretions of persons ill with, or suspected of having, cholera, and floors, etc., soiled with them, disinfect by copious (at least hourly) use of slaked lime or chlorinated lime solution (5 drachms chlorinated lime to 1 quart cold water), or other trusted disinfectants.

Linen, clothing, bedclothing, covers and the like, also such as come to you from cholera regions, send, well wrapped up and tied, to a public disinfecting institution.

If such is not within reach, soak the things 24 hours in soap and water (one pound washing soap to a pail of hot water), and then boil thoroughly.

Other soiled objects cleanse thoroughly with such

soapy water, with quicklime or carbolic acid solution. If the nature of the objects does not admit of this, then place them for at least six days in an unused, airy, dry place.

Thorough drying is unfavorable to the development of the disease germs.

5. If your digestion is disturbed, if you have diarrhœa, especially with vomiting or great nausea, consult a physician at once.

Until he comes, take a warm drink, put on a woolen bandage about your body, remain in your room; if in great distress, go to bed.

For relief, you may take a cup of tea, with cognac or rum. Let your food be a mucilaginous soup, also zwieback or stale white bread without butter.

If you have reliable (prepared from a physician's prescription) cholera drops at hand, take from 20 to 30 drops on sugar.

Keep your presence of mind, even if you are ill. Fright and cowardice act unfavorably on body and mind.

HAWAII.

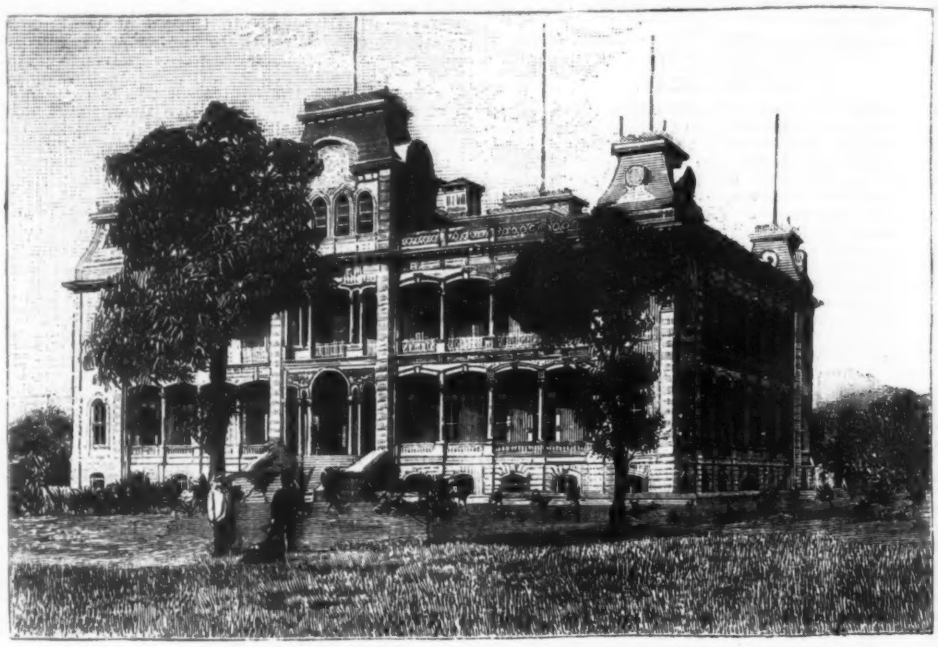
FRANK H. PALMER, Boston.

THE attention of the civilized world has been concentrated in the past few weeks on the little kingdom of Hawaii, now no longer a kingdom, but by the fault of the Queen, the favor of the President and Senate and the providence of God, likely soon to become an integral part of the United States. Curiosity and something better, namely, a real interest and desire for information about this far-off country has been awakened on all sides. Much has been published concerning it in the daily press consisting of about the usual proportions of truth and error. A few facts about the country and its inhabitants, together with a brief account of the causes which have led to the downfall of its sovereign, by one who has resided for two years at the capital of the Hawaiian kingdom will probably be of interest to the readers of *Education*.

The Hawaiian Islands* do not seem so far away after one has visited them as they do when vaguely thought of as somewhere in the vast Pacific Ocean, west of San Francisco. They are reached by a short seven days' voyage from the Golden Gate, in the large and comfortable steamers of the Pacific Mail and the Occidental and Oriental Steamship companies. It is well for the sake of accuracy to bear in mind the fact that they are in the *North* Pacific Ocean, between 18 degrees 54 minutes and 22 degrees 2 minutes north latitude and between 155 degrees and 161 degrees west longitude. A popular misconception, reproduced only last week in the editorial utterances of one of the largest New York dailies, classes them with the "South Sea" islands. They are nearly as far from the nearest

S. B. DOLE, PRESIDENT OF THE PROVISIONAL GOVERNMENT OF HAWAII

of the South Sea islands as they are from the American continent, and have no other connection with them than certain affinities of race and language. Another popular error is the impression that the native Hawaiians were formerly cannibals. It is probable that portions of Captain Cook's heart were tasted as a purely religious ceremony by the priests on the occasion of his assassination; but cannibalism in the sense of the regular eating of human flesh as food never existed, so far as is known, in these islands, and they should never be spoken of as "Cannibal Islands."



THE GOVERNMENT HOUSE, HONOLULU.

They are twelve in number and are of volcanic origin, having been thrown up in the midst of the vast expanse of waters in a line from the northwest to the southeast. The island of Kauai lies farthest to the northwest, and has much softer outlines than the other islands, owing to the erosive action of the winds and storms in the long ages since its formation. But as we proceed toward the southeast each island, in turn, presents fresher evidences of volcanic activity until we reach the last one of the group, the island of Hawaii, where the mighty volcano, Kilauea, is in a state of perpetual eruption, and probably has been since men dwelt on these shores.

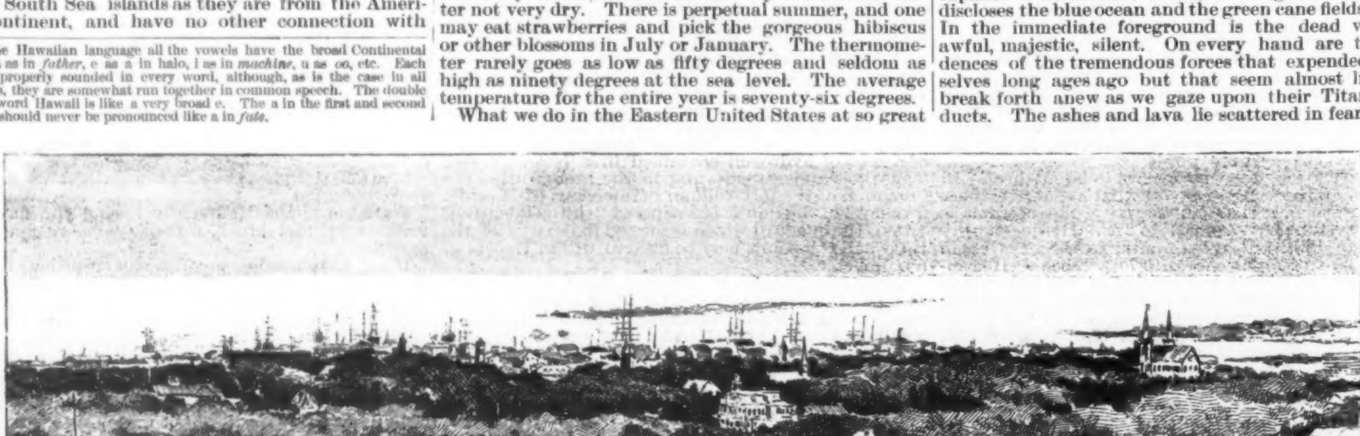
The several islands are very mountainous in the interior. The mountains are divided by deep, broad and fertile valleys which are filled with tropical vegetation. The orange, banana, pineapple, breadfruit, mango, tamarind, coco-palm, and many species of native trees and plants not found elsewhere, fill these valleys or fringe the sandy shores. There are almost perpetual rains at certain elevations along the mountain sides, and countless streams trickle down the declivities in silver ribbons or sparkling cascades, adding a most charming feature to the landscape and carrying fertility to the plains below. Often as the steamer approaches Honolulu the sun is shining on the sea and the rain falling on the mountains behind the city, with the beautiful and auspicious result of the formation of a bright rainbow which spans the fair Hawaiian capital. The climate is almost ideal. There is a wet and a dry season, the former not very wet and the latter not very dry. There is perpetual summer, and one may eat strawberries and pick the gorgeous hibiscus or other blossoms in July or January. The thermometer rarely goes as low as fifty degrees and seldom as high as ninety degrees at the sea level. The average temperature for the entire year is seventy-six degrees.

What we do in the Eastern United States at so great an expenditure of time, money and patience in equalizing the temperature, summer and winter, is all done on an immense scale by nature in the Hawaiian Islands. A trade wind blows for nine months in the year, coming over thousands of miles of ocean where it has washed itself clean and sweetened its breath so that it brings purity and health to all upon the land. The climate is highly recommended for persons affected with pulmonary complaints. The island of Maui contains the largest extinct volcanic crater, and the island of Hawaii the largest constantly active volcano in the world. The famous "Haleakala" is a huge circular wall nineteen miles in circumference and ten thousand feet high. The scenery from the summit of this lofty mountain is grand and awe-inspiring in the extreme. The traveler gazes off over the boundless

QUEEN LILIUOKOLANI.

expanse of cloud land, which, dividing here and there, discloses the blue ocean and the green cane fields below. In the immediate foreground is the dead volcano, awful, majestic, silent. On every hand are the evidences of the tremendous forces that expended themselves long ages ago but that seem almost likely to break forth anew as we gaze upon their Titanic products. The ashes and lava lie scattered in fearful and

* In the Hawaiian language all the vowels have the broad Continental sound; a as in *father*, e as a in halo, i as in *machine*, u as *oo*, etc. Each vowel is properly sounded in every word, although, as is the case in all languages, they are somewhat run together in common speech. The double ii in the word Hawaii is like a very broad e. The a in the first and second syllables should never be pronounced like a in *fate*.



GENERAL VIEW OF HONOLULU.

fantastic contortions on the crater's floor. Three or four subsidiary cones in the bottom of the pit look as though their fiery hearts might burst forth again at any moment. The entire top of the mountain appears to have been blown off and the side in one place to have been rent by some tremendous explosion of by-gone ages. The flesh lava flowing out and cooling in the waters of the ocean has formed a new promontory in the sea. But there has been no activity in this volcano within the memory or tradition of man. As long as men have lived here this mighty crater has stood a silent and majestic sentinel in the midst of the sea.

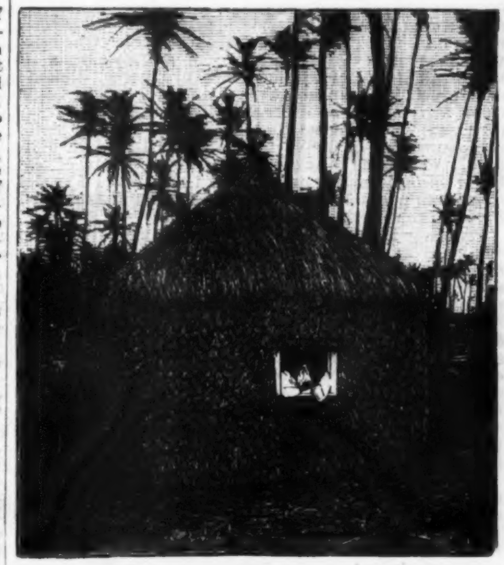
Kilauea, the great constantly active volcano of Hawaii, varies so perpetually that if it should be described as the writer saw it in 1877 the description would probably fail in many points to tally with that of any of the multitudes of travelers who have visited it since. It is not a *terminal* crater, that is, it is not, as the geographies have usually pictured volcanoes to the school children, a mountain with the smoke ascending from a hole in the top like a huge chimney, but it is situated on a plain about 4,000 feet above the sea level on the side of Mauna Loa. At the summit of this majestic mountain is a terminal crater of tremendous proportions, called Mokuaweoweo. On the whole this mountain, with its two awful craters, is the grandest and most impressive terrestrial object the writer has ever beheld. It is nearly three miles high and its base is one hundred and eighty miles in circumference.

It rises right out of the sea, whose dead level brings out in contrast the vast height and dimensions of the mountain as the traveler approaches it on shipboard.

Kilauea is "a great pit on a rolling plain," nine miles in circumference and about a thousand feet deep. It has a floor of hardened lava which resembles the ice on a lake or pond. This lava crust covers an area of about six square miles at its lowest depth. It is cracked here and there and is hot to the soles of the feet as one walks over it. Through the cracks come the lurid glare and the sulphurous gases from the seething, molten mass below. In the southern portion of the crater is Halemaumau, or the lake of perpetual fire. This is about one-half a mile in width and is in a state of continual and frightful ebullition. Dense clouds of smoke roll up from the pit below the awe-struck beholder. Hideous roarings, cracklings, hissings and groanings deafen his ears. Unbreathable gases and fumes of sulphur assail his nostrils. In momentary glimpses when he can open his eyes he beholds a wallowing mass of molten matter, rolling and seething, spouting up in fiery fountains, subsiding again into unstable levels, the whole molten mass now converging into the center and now separating under the influence of some mighty centrifugal force in parting streams and torrents and surges which roll and pitch and dash against each other and lash the sides of their immense caldron as though they were so many angry imprisoned monsters. Once, in their adventuresome zeal, a party of visitors leaped a fissure a foot or two wide and of unknown depth, which divided a ledge or crag of lava overhanging the lake from the comparatively firm old lava crust, and essayed to look down from that vantage ground into the awful fires below. Suddenly as they gazed a dull sound as of a surge striking the foot of the crag caused them to leap back. Hardly had their feet left the ledge when the latter crumbled like so much melting snow and fell in, with hideous hissings and contortions, and was swallowed up in the fiery mass below.

Kilauea is becoming celebrated as one of the great natural wonders of the world. It is visited by an increasing number of tourists each year. The trip from San Francisco to Honolulu (2,080 miles) costs $75 for first cabin passage and about half as much for steerage. A round trip ticket, good for three months, can be had for $125. A round trip ticket to Honolulu and Kilauea, covering all expenses for five weeks, costs $225.

Much has been written about the lepers of Molokai. This terrible disease was undoubtedly introduced by dissolute sailors who visited the islands before modern methods of communication had brought them near to the rest of the world. Some one has pointed out the significant fact that civilized nations send the heathen



A GRASS HUT, HAWAII.

their vices and their diseases before they send them their virtues and their civilization. The natural tendencies of the Hawaiian race toward sensuality, and the customs and habits common to all tribes who live in a perpetually warm climate, combined with a certain insensibility to the danger of contagion, have made these people the ready and easy victims of this loathsome disease. The government has made an earnest effort to segregate the lepers, and, with this end in view, has established a leper settlement on the island of Molokai, in a broad and fertile plain shut in by impassable mountains and a harborless shore. Here are gathered about one thousand men and women, doomed to this horrible, lingering disease with which science in despair has almost ceased to grapple.

Yet there is some relief to the dark picture. There is a sort of apathy which goes with the disease. The victim often lives several years, and after the first pangs of homesickness have passed away the lepers of Molokai put a cheerful face on the matter and settle down to their new conditions of life with a considerable degree of contentment and grace. The disease is hardly more contagious than consumption or cancer if one leads a clean and decent life.

The key to the right understanding of recent political events is found in the patent fact that the Hawaiians are a race of grown-up children, and are unfitted for self-government. The missionaries landed in April, 1820. The natives had just cast off their idolatry in consequence of a natural reaction against the enormities and abuses involved in the old order of things. They readily embraced Christianity and the rudiments of civilization. Their language was reduced to writing, and they learned to read and write. But they have not developed to any considerable extent the deeper qualities of mind and character. For years they obediently followed the advice of their leaders and teachers, who were chiefly from the United States, and a distinctly American tone was given to all their institutions. But in the last ten or a dozen years, feeling their numerical majority and becoming more or less affected by the desires and ambitions awakened by an era of great financial prosperity, they have become more or less restive and impatient of restraint. In this juncture adventurers and unprincipled men have gained influence with the rulers and fomented jealousies and suggested wild and extravagant schemes. This has resulted in an uprising of the sober, diligent, influential and property-holding citizens, who have abrogated the monarchy, and, in order that there may be a stable and permanently peaceful government, are seeking a close alliance with the United States. This revolution is simply a triumph of righteousness over ignorance, selfishness, and flagrant and open sin. The party overthrown is the free opium, free rum, and lottery license party. Those who have taken charge of affairs are men of character, who are in no sense adventurers, and who have at heart the real good of the Hawaiians as much as their own interests. They have the support of all the best classes in the community, including the more intelligent Hawaiians. The importance of these islands to the United States grows out of their strategic position in the commerce of the Pacific. North of the equator and between America and Asia, they are the only land in that vast expanse, the only port at which a ship can touch. They have a harbor capable of protecting the navies of the world, and, in case of war, would be indispensable for a coaling and supply station. On the completion of the Nicaragua canal, if not before, a Pacific cable is inevitable. The Hawaiian Islands will then make the only break in the tremendous stretch of 7,600 miles between Nicaragua and Japan. The objection to their annexation, which is founded on the supposed policy of our country not to annex foreign territory, seems to be answered by the fact that we have annexed Alaska, which is farther from us than Hawaii and from which we are separated by British possessions, while only an unobstructed ocean divides us from these fair islands that hold so many important relations to our growing national life.—*Education.*

A PALM TREE WALK, HONOLULU.

ESTIMATES OF GEOLOGIC TIME.*

By WARREN UPHAM.

ACCORDING to Sir Archibald Geikie, in his presidential address before the British Association last August,† the known rates of deposition of sediments imply that for the formation of all the stratified rocks of the earth's crust a duration somewhere between 73,000,000 and 680,000,000 years must be required. Most geologists, before specially looking into this subject, would doubtless regard the lowest of these estimates as a minimum of the time needed for the processes of deposition and of erosion revealed by their study of the rocks, and for the concurrent changes of the earth's floras and faunas from their beginning to the present time. But to some geologists these figures seem far too small, among whom Mr. W. J. McGee, in a paper read before the American Association the same month,‡ reasoning from similar premises of geologic observations, would claim about seven thousand millions of years as the more probable measure of the part of the earth's duration since its earliest fossiliferous rocks were formed, and probably twice as long time since the earth began its planetary existence.

On the other hand, the most eminent writers who have considered this subject from the standpoint of physical experiment and theory and their relationship with astronomy, including Thomson, Tait, Newcomb, Young, and Ball, tell us that geologists can be allowed probably no more than 100,000,000 of years, and perhaps only about 10,000,000, since our earth was so cooled as to permit the beginning of life upon it.

It is comparatively easy to determine the ratios or relative lengths of the successive geologic eras, but is confessedly very difficult to decide beyond donbt even the approximate length in years of any part of the records of the rock strata. The portions for which we have the best means of determining their length are the Glacial and Recent periods, the latter extending from the Champlain epoch, or closing stage of the Ice age, to the present time, while these two divisions, the Glacial or Pleistocene period and the Recent, make up the Quaternary era. If we can only ascertain somewhat nearly what has been the duration of this era, from the oncoming of the Ice age until now, it will serve as a known quantity to be used as the multiplier in the several ratios for giving us the approximate or probable measures in years for the recedingly earlier and far longer Tertiary, Mesozoic, Paleozoic, and Archæan eras, which last takes us back almost or quite to the time when the cooling molten earth became first enveloped with a solid crust.

Sir William Thomson (now Lord Kelvin) long ago estimated, from his study of the earth's internal heat, its increase from the surface downward, and the rate of its loss by radiation into space, that the time since the consolidation of the surface of the globe has been somewhere between 20,000,000 and 400,000,000 of years, and that most probably this time and all the geologic record must be limited within 100,000,000 years.§

Prof. George H. Darwin computes, from the influence of tidal friction in retarding the earth's rotation, that

* Abridged from a paper in the Bibliotheca Sacra, January, 1893.

† *Nature*, Aug. 4, 1892, vol. xlvi., pp. 317-328.

‡ *Am. Anthropologist*, October, 1892, vol. v., pp. 327-344, with a plate showing relative durations of natural time units, historical eras, and geological periods.

§ In an article published two months ago in this *Journal*, since the present paper was written, Mr. Clarence King, from recent physical investigations of diabase when subjected to great heat and pressure, concludes that the age of the earth, deduced by Lord Kelvin's method, is approximately 24,000,000 years.

probably only 57,000,000 years have elapsed since the moon's mass was shed from the revolving molten earth, long before the formation of its crust. From the same arguments and the rate at which the sun is losing its store of heat, Prof. Guthrie Tait affirms that apparently 10,000,000 years are as much as physical science can allow to the geologist. Prof. Newcomb, summing up the results of these physical and astronomical researches, writes: "If the sun had, in the beginning, filled all space, the amount of heat generated by his contraction to his present volume would have been sufficient to last 18,000,000 years at his present rate of radiation . . . . 10,000,000 years . . . is, therefore, near the extreme limit of time that we can suppose water to have existed on the earth in the fluid state."

Not only the earth, but even the whole solar system, according to Newcomb, "must have had a beginning within a certain number of years which we cannot yet calculate with certainty, but which cannot much exceed 20,000,000, and it must end."*

The geologist demurs against these latter far too meager allotments of time for the wonderful, diversified, and surely vastly long history which he has patiently made out in his perusal of the volume of science disclosed by the rocks. He can apparently do very well with Lord Kelvin's original estimate, but must respectfully dissent from the less liberal opinions noted. Somewhere in the assumed premises which yield to mathematicians these narrow limits of time there must be conditions which do not accord with the actual constitution of the sun and earth. It must be gratefully acknowledged, however, in the camp of the geologists, that we owe to these researches a beneficial check against the notion once prevalent that geologic time extends back practically without limit; and it is most becoming for us carefully to inquire how closely the apparently conflicting testimonies of geology and of physics may be brought into harmony by revision of each.

Among all the means afforded by geology for direct estimates of the earth's duration, doubtless the most reliable is through comparing the present measured rate of denudation of continental areas with the aggregate of the greatest determined thicknesses of the strata referable to the successive time divisions. Now the rates at which rivers are lowering the altitudes of their basins by the transportation of sediments to the sea vary from an average of one foot taken from the sand surface of its hydrographic basin by the River Po in 730 years to one foot by the Danube in 6,800 years. As a mean for all the rivers of the world, Alfred Russel Wallace assumes that the erosion from all the land surface is one foot in 3,000 years. The sediments are laid down in the sea on an average within 30 miles from the coast, and all the coast lines of the earth have a total measured length, according to Dr. James Croll and Mr. Wallace, of about 100,000 miles; so that the deposition is almost wholly confined to an area of about 3,000,000 square miles. This area is one-nineteenth as large as the earth's total land area; hence it will receive sediment nineteen times as fast as the land is denuded, or at the rate of about nineteen feet of stratified beds in 3,000 years, which would give one foot in 158 years.

With this Wallace compares the total maxima of all the sedimentary rocks of the series of geologic epochs, measured in whatever part of the earth they are found to have their greatest development. Prof. Samuel Haughton estimates their aggregate to be 177,200 feet, which multiplied by 158 gives approximately 28,000,000 years as the time required for the deposition of the rock strata in the various districts where they are thickest and have most fully escaped erosion and redeposition.

Most readers, following this argument, would infer that it must give too large rather than too scanty an estimate of geologic duration; but to many students of the earth's stratigraphy it seems more probably deficient than excessive. All must confess that the argument rests upon many indeterminate premises, since the total extent of the land areas and the depths of the oceans have probably been increasing through the geologic areas, and the effects of tides have probably diminished. The imperfection of the geologic record, so impressively shown by Charles Darwin in respect to the sequence of plants and animals found fossil in the rocks, will also be appealed to as opposing the assumption that the 177,200 feet, or 33⅓ miles, of strata represent the whole, or indeed any more than a small fraction of the earth's history. To myself, however, this last objection seems unfounded, since in many extensive and clearly conformable sections observed on a grand scale in crossing broad areas, there is seen to have been evidently continuous deposition during several or many successive geologic epochs, and by combining such sections from different regions a record of sedimentation is made wellnigh complete from the earliest Paleozoic morning of life to its present high noon. But perhaps we may do better to change somewhat the premises of our computation, in view of the extensive regions where the rock strata remain yet to be thoroughly explored, and because of certain large land tracts having little rain and therefore no drainage into the sea. Let us assume that the total maxima of strata amount to 50 miles, and that the mean rate of the land denudation is only one foot in 6,000 years; and we then obtain a result three times greater than before, or about 84,000,000 years for the deposition of the stratified rocks.

As a confirmation of the validity of his estimate of 28,000,000 years, Wallace cites the estimates differently obtained through the geologic time ratios of Lyell and Dana, in combination with Dr. Croll's astronomic theory of the causes of the Ice age, which attributes the accumulation of ice sheets to stages of high eccentricity of the earth's orbit. The Quaternary Glacial period is assigned by this theory an extent of about 160,000 years, from 240,000 to 80,000 years ago. The next preceding epoch of great eccentricity was about 850,000 years ago, and to that time are referred large ice-borne blocks in Miocene strata of northern Italy. The union of this assumption with the time ratios for the Tertiary and earlier eras is explained as follows by Wallace in "Island Life," Chapter X.:

"Sir Charles Lyell, taking the amount of change in the species of mollusca as a guide, estimated the time elapsed since the commencement of the Miocene as one-third that of the whole Tertiary epoch, and the latter at one-fourth that of geological time since the Cambrian period. Professor Dana, on the other hand, estimates the Tertiary as only one-fifteenth of the Mesozoic and Paleozoic combined. On the estimate above given (that the time since a Miocene glacial epoch has been 850,000 years), founded on the dates of phases of high eccentricity, we shall arrive at about 4,000,000 years for the Tertiary epoch, and 16,000,000 years for the time elapsed since the Cambrian, according to Lyell, or 60,000,000 according to Dana. The estimate arrived at from the rate of denudation and deposition (28,000,000 years) is nearly midway between these, and it is, at all events, satisfactory that the various measures result in figures of the same order of magnitude, which is all one can expect on so difficult and exceedingly speculative a subject. . . The time thus arrived at is immensely less than the usual estimates of geologists, and is so far within the limits of the duration of the earth as calculated by Sir William Thomson as to allow for the development of the lower organisms an amount of time anterior to the Cambrian period several times greater than has elapsed between that period and the present day."

Professor Haughton has estimated time ratios from two series of data. His results deduced from the maximum thickness of the strata for the three grand divisions of Archæan, Paleozoic, and subsequent time, expressed in percentages, are 34·3 : 42·5 : 23·2; and from his computations as to the secular cooling of the earth, 33·0 : 41·0 : 26·0. From his consideration of the present rates of denudation and the maximum thickness of the strata, he obtains "for the whole duration of geological time a minimum of 200,000,000 of years." In my opinion, this is a large rather than a small total estimate; but the length of Archæan or pre-Cambrian time seems to me proportionately much greater than is here allowed.

The ratios reached by Profs. J. D. Dana and Alexander Winchell, from the thicknesses of the rock strata, are closely harmonious, the durations of Paleozoic, Mesozoic and Cenozoic time being to each other as 12 : 3 : 1. The Tertiary and Quaternary ages, the latter extending to the present day, are here united as the Cenozoic era. Professor Dana has further ventured a supposition that these three vast eras, from the Cambrian dawn until now, may comprise some 48,000,000 years, which would give for the Paleozoic era, 36,000,000 years; the Mesozoic, 9,000,000; and the Cenozoic, 3,000,000. He disclaims, however, any assumption that those figures are "even an approximate estimate of the real length of the interval, but only of relative lengths, and especially to make apparent the fact that these intervals were *very long*."*

Prof. W. M. Davis, without speaking definitely of the lapse of time by years, endeavors to give some conception of what these and like estimates of geologic ratios really mean, through a translation of them into terms of a linear scale.† Starting with the representation of the Postglacial or Recent period, since the North American ice sheet was melted away, as two inches, he estimates that the beginning of the Tertiary erosion of the Hudson River gorge through the Highlands would be expressed by a distance of 10 feet; that the Triassic reptilian tracks in the sandstone of the Connecticut valley would be probably 50 feet distant; that the formation of the coal beds of Pennsylvania would be 80 or 100 feet back from the present time; and that the Middle Cambrian trilobites of Braintree, Mass., would be 200, 300 or 400 feet from us.

Having such somewhat definite and agreeing ratios, derived from various data by different investigators, can we secure the factor by which they should be multiplied to yield the approximate duration of geologic epochs, periods and eras in years? If on the scale used by Professor Davis we could substitute a certain time for the period since the departure of the ice sheet, we should thereby at once determine, albeit with some vagueness and acknowledged latitude for probable error, how much time has passed since the Triassic tracks were made, the coal deposited, and the trilobites entombed in the Cambrian slates. Now just this latest and present division of the geologic record, following the Ice age, is the only one for which geologists find sufficient data to permit direct measurements or estimates of its duration. "The glacial invasion from which New England and other northern countries have lately escaped," remarks Davis, "was prehistoric, and yet it should not be regarded as ancient."

In various localities we are able to measure the present rate of the erosion of gorges below waterfalls, and the length of the postglacial gorge divided by the rate of recession of the falls gives approximately the time since the Ice age. Such measurements of the gorge and falls of St. Anthony by Prof. N. H. Winchell show the length of the Postglacial or Recent period to have been about 8,000 years; and from the surveys of Niagara Falls, Mr. G. K. Gilbert believes it to have been 7,000 years, more or less. From the rates of wave cutting along the sides of Lake Michigan, and the consequent accumulation of sand around the south end of the lake, Dr. E. Andrews estimates that the land there became uncovered from its ice sheet not more than 7,500 years ago. Prof. G. Frederick Wright obtains a similar result from the rate of filling of kettle holes among the gravel knolls and ridges called kames and eskers, and likewise from the erosion of valleys by streams tributary to Lake Erie; and Prof. B. K. Emerson, from the rate of deposition of modified drift in the Connecticut valley at Northampton, Mass., thinks that the time since the Glacial period cannot exceed 10,000 years. An equally small estimate is also indicated by the studies of Gilbert and Russell for the time since the last great rise of the Quaternary lakes, Bonneville and Lahontan, lying within the arid Great Basin of interior drainage, which are believed to have been contemporaneous with the great extension of ice sheets upon the northern part of our continent.

Prof. James Geikie maintains that the use of palæolithic implements had ceased, and that early man in Europe made neolithic (polished) implements, before the recession of the ice sheet from Scotland, Denmark, and the Scandinavian peninsula; and Prestwich suggests that the dawn of civilization in Egypt, China and India may have been coeval with the glaciation of northwestern Europe. In Wales and Yorkshire the amount of denudation of limestone rocks on which bowlders lie has been regarded by Mr. D. Mackintosh as proof that a period of not more than 6,000 years has elapsed since the bowlders were left in their positions. The vertical extent of this denudation, averaging about six inches, is nearly the same with that observed in the southwest part of the Province of Quebec by Sir William Logan and Dr. Robert Bell, where veins of quartz marked with glacial striæ stand out to various heights not exceeding one foot above the weathered surface of the inclosing limestone.

Another indication that the final melting of the ice sheet upon British America was separated by only a very short interval, geologically speaking, from the present time, is seen in the wonderfully perfect preservation of the glacial striation and polishing on the surfaces of the more enduring rocks. Of their character in one noteworthy district, Dr. Bell writes as follows: "On Portland promontory, on the east coast of Hudson's Bay, in latitude 58°, and southward the high rocky hills are completely glaciated and bare. The striæ are as fresh looking as if the ice had left them only yesterday. When the sun bursts upon these hills after they have been wet by the rain, they glitter and shine like the tinned roofs of the city of Montreal."*

From this wide range of concurrent but independent testimonies, we may accept it as practically demonstrated that the ice sheets disappeared from North America and Europe some 6,000 to 10,000 years ago. But having thus found the value of one term in our ratios of geologic time divisions, we may know them all approximately by its substitution. The two inches assumed to represent the postglacial portion of the Quaternary era may be called 8,000 years; then, according to the proportional estimates by Davis, the Triassic period was probably 2,400,000 years ago; the time since the Carboniferous period has been about 4,000,000 or 5,000,000 years; and since the middle of the Cambrian period, twice or perhaps four times as long. Continuing this series still farther back, the earliest Cambrian fossils may be 20,000,000 or 25,000,000 years old, and the beginning of life on our earth was not improbably twice as long ago.

Seeking to substitute our measure of postglacial time in Prof. Dana's ratios, we are met by the difficulty of ascertaining first its proportion to the preceding Glacial period and then the ratio which these two together bear to the Tertiary era. It would fill a very large volume to rehearse all the diverse opinions current among glacialists concerning the history of the Ice age, its wonderful climatic vicissitudes, and the upward and downward movements of the lands which are covered with the glacial drift. Many eminent glacialists, as James Geikie, Wahnschaffe, Penck, De Geer, Chamberlin, Salisbury, Shaler, McGee, and others, believe that the Ice age was complex, having two, three, or more epochs of glaciation, divided by long interglacial epochs of mild and temperate climate when the ice sheets were entirely or mainly melted away. Professor Geikie, in a recent very able paper,† claims five distinct glacial epochs, as indicated by fossiliferous beds lying between deposits of till, and by other evidences of great climatic changes. In this country Mr. McGee recognizes at least three glacial epochs. The astronomic theory of Croll attributes the accumulation of ice sheets to recurrent cycles which bring the earth alternately into aphelion and perihelion each 21,000 years during the periods of maximum eccentricity of the earth's orbit. Its last period of this kind, as before stated, was from about 240,000 to 80,000 years ago, allowing room for seven or eight such cycles and alternations of glacial and interglacial conditions. The supposed evidence of interglacial epochs, therefore, gave to this theory a wide credence; but the recent determinations of the geologic brevity of the time since the ice sheets disappeared from North America and Europe make it clear in the opinions of some of the geologists who believe in the duality or plurality of Quaternary glacial epochs that not astronomic but geographic causes produced the Ice age.

Glacialists who reject Croll's ingenious and brilliant theory mostly appeal to great preglacial altitude of the land as the chief cause of the ice accumulation, citing as proof of such altitude the fiords and submarine valleys which on the shores of Scandinavia and the Atlantic, Arctic and Pacific coasts of North America, descend from 1,000 to 3,000 and even 4,000 feet below the sea level, testifying of former uplifts of these continental areas so much above their present heights. But beneath the enormous weight of their ice sheets these lands sank, so that when the ice attained its maximum area and thickness and during its departure the areas on which it lay were depressed somewhat lower than now, and have since been re-elevated. This view to account for the observed records of the Ice age is held by Dana, LeConte, Wright, Jamieson, and others, including the present writer. It is believed to be consistent either with the doctrine of two or more glacial epochs during the Quaternary era or with the reference of all the glacial drift to a single glacial epoch, which is thought by Wright, Prestwich, Lamplugh, Falsan, Holst, and others to be more probable. To myself, though formerly accepting two glacial epochs, with a long warm interval between them, the essential continuity of the Ice age seems now the better provisional hypothesis, to be held with candor for weighing evidence on either side. The arguments supporting this opinion are well stated by Professor Wright.‡ If there was only one epoch of glaciation, with moderate temporary retreats and readvances of the ice border, sufficient to allow stratified beds with the remains of animals and plants to be intercalated between accumulations of till, the duration of the Ice age may only have comprised a few tens of thousands of years. On this point Professor Prestwich has well written as follows:

"For the reasons before given, I think it possible that the Glacial epoch—that is to say, the epoch of extreme cold—may not have lasted longer than from 15,000 to 25,000 years, and I would for the same reasons

* "Popular Astronomy," pp. 505-519; "Astronomy for Schools and Colleges," p. 501.

* Manual of Geology, p. 795.

† *Atlantic Monthly*, July, 1891, p. 77.

* Bulletin, Geol. Society of America, vol. i., p. 308.

† "On the Glacial Succession in Europe," Trans. Royal Society of Edinburgh, 1892, vol. xxxvii., pp. 127-149, with map.

‡ The Ice Age in North America, 1889, chapters xix. and xx. Man and the Glacial Period, 1892, pp. 117-120 and chapters ix. and x. "Unity of the Glacial Epoch," in this Journal, Nov., 1892.

limit the time of . . . . . . the melting away of the ice sheet to from 8,000 to 10,000 years or less."[†]

From these and foregoing estimates which seem to me acceptable, we have the probable length of Glacial and Post-glacial time together 30,000 or 40,000 years, more or less; but an equal or considerably longer preceding time, while the areas that became covered by ice were being uplifted to high altitudes, may perhaps with good reason be also included in the Quaternary era, which then would comprise some 100,000 years. The best means for learning the relative lengths of Tertiary and Quaternary time I think to be found in the changes of faunas and floras since the beginning of the Tertiary era, using especially the marine molluscan faunas as most valuable for this comparison. Scarcely any species of marine mollusks have become extinct or undergone important changes during the glacial and recent periods, but since the Eocene dawn of the Tertiary nearly all of these species have come into existence. Judged upon this basis, the Tertiary era seems probably fifty or a hundred times longer than the Ice age and subsequent time; in other words, it may well have lasted two millions or even four millions of years. Taking the mean of these numbers, or three million years, for Cenozoic time, or the Tertiary and Quaternary ages together, we have precisely the value of Professor Dana's ratios which he himself assumes for conjectural illustration, namely, 48,000,000 years since the Cambrian period began. But the diversified types of animal life in the earliest Cambrian faunas surely imply a long antecedent time for their development on the assumption that the Creator worked before then as during the subsequent ages in the evolution of all living creatures. According to these ratios, therefore, the time needed for the deposition of the earth's stratified rocks and the unfolding of its plant and animal life must be about a hundred millions of years.

Reviewing the several results of our different geologic estimates and ratios supplied by Lyell, Dana, Wallace and Davis, we are much impressed and convinced of their approximate truth by their somewhat good agreement among themselves, which seems as close as the nature of the problem would lead us to expect, and by their all coming within the limit of 100,000,000 years which Sir William Thomson estimated on physical grounds. This limit of probable geologic duration seems therefore fully worthy to take the place of the once almost unlimited assumptions of geologists and writers on the evolution of life, that the time at their disposal has been practically infinite. No other more important conclusion in the natural sciences, directly and indirectly modifying our conceptions in a thousand ways, has been reached during this century.

The error by which Mr. McGee, in the estimate stated in the early part of this article, wanders so far astray, consists in his relying largely on Dr. Croll's theory for the cause of the glacial period, whereby he concludes that this period was of great length and that the ice sheets were due to astronomic conditions, while the land through the ice age had somewhat approximately its present height, with only moderate uplifts and depressions. Drawing his ratios of post-glacial and glacial time, and of the preceding early Quaternary or late Tertiary epoch to which the Lafayette formation belongs, from the amounts of stream erosion, he has supposed the conditions then similar to those of the present time, so that the relative durations of these epochs may be estimated from their excavations of valleys by watercourses. But it seems preferable, as before noted, to refer the Ice age to great elevation of the land, whereby the erosion of streams would be caused to proceed very much more rapidly than if the country were as low as now. With an altitude of our Atlantic coastal plain and whole continental area westward 3,000 feet higher than now, the valley cutting may have gone forward twenty or a hundred times faster than to-day, or even near the coast a thousand times faster than now. The factor with which Mr. McGee starts on the multiplication of the earlier ratios to change them to years is evidently far too large, and it gives therefore for all the geologic eras and for the earth's total age too vast figures probably by twenty-fold to a hundredfold.

Anthropologists, not less than geologists, have a lively interest in the estimates and measurements of the length of the Glacial and Recent periods, for the earliest reliable testimony of man's existence comes to us from the Ice age, both in North America and Europe. Confining our attention to the observations which prove that men were living on our continent as contemporaries of its northern ice sheet, we have many independent and widely separated localities where traces of man's presence during the Glacial period have been found. Under the beach ridge of gravel and sand on the south side of Lake Iroquois, the Glacial representative of Lake Ontario, charred sticks, with ashes and stones laid to form a rude hearth, were discovered about 18 feet below the surface in digging a well in Gaines township, Orleans County, N. Y. Lake Iroquois was dammed on the northeast by the receding continental ice sheet and outflowed by way of the Mohawk and Hudson. The hearth and fire were made, according to Mr. G. K. Gilbert, "not long after the establishment of the Mohawk outlet and during its continuance."[*] To a much earlier stage of the glacial recession we must refer the extensive gravel deposits of the Delaware River in the vicinity of Trenton, N. J., in which Dr. C. C. Abbott, Professor F. W. Putnam and others have found many palæolithic implements and chipped fragments of argillite.[†] Somewhat farther south, in Delaware, Mr. Hilborne T. Cresson has found similar palæoliths in glacial gravel belonging to a still earlier part of the Ice age, probably deposited during the maximum extension of the ice sheet. Other localities where palæoliths have been discovered in glacial gravel and sand beds, formed during the departure of the ice, are Newcomerstown, on the Tuscarawas River, in eastern Ohio; on the Little Miami River at Loveland and Madisonville, in southwestern Ohio; on the east fork of the White River at Medora, in southern Indiana, and on the upper Mississippi at Little Falls, in central Minnesota. Again, in one of the beach ridges of the glacial Lake Agassiz, held in the basin of the Red River of the North and of Lake Winnipeg by the barrier of the waning ice sheet, Mr. J. B. Tyrrell has found chipped fragments of quartzite, evidently of human workmanship, contemporaneous with the rounded gravel and wave-worn sand of the beach. West of the Rocky Mountains, also, an obsidian spear head was discovered by McGee in the sediment of the Quaternary Lake Lahontan; and stone mortars, pestles and even human bones, including the famous Calaveras skull, have been obtained by Whitney, King, Becker, Wright and others, from the gold-bearing gravels under the lava of Table Mountain, California. Though these last are south of the continental drift sheet, they seem referable on sufficient geologic evidences to the Pleistocene or Glacial period.

At one time the Californian discoveries were believed by some to prove man's presence there during the Pliocene period, far longer ago than the Ice age; but no indisputable proof, nor even apparently reliable evidence, for so great antiquity of man has been brought to light in any part of the world. *Homo sapiens*, as Professor LeConte stated in discussions of this subject at the meeting of the American Association last August, in Rochester, N. Y., must be regarded, in the present stage of our knowledge, as restricted to the Quaternary era, although his anthropoid ancestors may have begun as far back as in Pliocene or Miocene time their ascent toward man's present intellectual and spiritual eminence.—*American Journal of Science.*

* Geology, vol. ii., p. 534.

† Since this paper was written, two articles by Mr. W. H. Holmes in *Science* (November 25, 1892, and January 20, 1893) lead me to uncertainty whether the traces of man's existence in this country during the Glacial period are referable, as has been hitherto supposed, to a technically palæolithic stage of culture. They seem to me to prove undubitably that men were living here contemporaneous with the ice sheet, but these men may have possessed the skill to make both rough and polished implements of stone, corresponding with the Neolithic age in Europe. The wide geographic range of the native American race, its differentiation into many divergent branches, and the very remarkable advances of some of them toward civilization before the discovery by Columbus, as in Mexico, Central America and Peru, indicate that the original peopling of the continent, which was apparently by migration from northeastern Asia, took place before the culmination of the Glacial period, probably during an immediately preceding time of general elevation of northern countries, so that land extended across the present areas of Bering Strait and Sea. It may well be true, but probably cannot be proved, that even at that early time the people taking possession of North and South America had attained the stage of culture characterized by the partial use of polished stone implements.

DETECTION OF LEAD.

AT a recent meeting of the Society of Chemical Industry, London section, a paper was communicated by Mr. R. Warington, F.R.S., who, for the nonce, had transferred his connection with Sir John Bennet Lawes from Rothamsted to the citric acid works at Millwall. It was owing to the continued uncertainty regarding the detection of lead in these acids, which had not been removed by the Chemical Committee of the London Chamber of Commerce, that Mr. Warington had taken the subject up.

First addressing himself to the various pharmacopœial processes, he found that the modes given therein differed widely, although they all depend upon the precipitation of the lead as sulphide. Thus, the German Pharmacopœia directs ammonia to be added to the solution of the acid so as to leave it slightly acid in reaction, and then to add sulphureted hydrogen solution. This serves well enough for citric acid, but the effect in the case of tartaric acid is simply to precipitate ammonium acid tartrate, whereby the lead reaction is obscured. The United States Pharmacopœia directs lead to be estimated in the ash left on incinerating the acids. Mr. Warington criticised those and other tests in detail, and pointed out that different results follow the use of sulphureted hydrogen gas and a watery solution of the same.

The strength of the acid solution also materially affects the result, and it may be said that the stronger the acid solution is the more lead would escape detection. Thus, in the case of tartaric acid 50 grammes made up with water to 100 c. c. and passing sulphureted hydrogen gas through it, we can just detect lead in the proportion of 72 parts per million, but 80 parts with certainty; a 25 grammes in 100 c. c. solution just shows 24 parts per million; and a 10 grammes in 100 c. c. shows 10 parts per million, and 5 parts of lead can almost be detected.

Citric acid reveals lead much more delicately. For example, the following figures were quoted:

In a solution of 50 grammes in 100 c. c. 20 parts per million of lead could be detected.

In a solution of 10 grammes in 100 c. c. 10 parts per million of lead could be detected (distinctly).

In a solution of 10 grammes in 100 c. c. 5 parts per million of lead could be detected (slightly).

By using sulphureted hydrogen solution lead can be detected with even greater delicacy. Thus, dissolve 10 grammes of tartaric acid in 20 c. c. of water, and make up to 100 c. c. with sulphureted hydrogen solution; 5 of lead in a million can thus be detected, and 10 per million with certainty. In the same way with citric acid 2 parts per million can be just detected, and 4 parts very readily.

Incidentally Mr. Warington said that at Messrs. J. B. Lawes & Co.'s factory, where these acids have recently been produced "lead-free," sulphureted hydrogen is used for eliminating the lead, and he found that the mother liquors contain a peculiar sulphur compound of a yellow color which prevents the further precipitation of lead. What this compound is he had not been able to ascertain. Again, speaking of the German Pharmacopœia test, he said there seemed to be the elements of a better method in it than the use of sulphureted hydrogen alone, and by adding alkali to saturation he had thought it possible to make it useful. But there came in a difficulty in that he could not obtain ammonia and caustic soda which did not give a brown reaction with sulphureted hydrogen. Ultimately he obtained a pure liquor ammon. from Hopkin & Williams, and an ammonium carbonate, almost pure, from Burgoyne, Burbidges & Co. Probably the irreconcilable results by different analysts were due to impure reagents. His experiments on working in alkaline solutions resulted in the discovery that half a part of lead per million can be so detected. There was, of course, the question of iron and other metals which react similarly with ammonium sulphide to be considered, and to get rid of them he boiled the solution with potassium cyanide, whereby iron is converted into ferrocyanide and its precipitation by the ammonium sulphide prevented. The same treatment also prevents the interference of copper.

Next dealing with the quantitative estimation of lead, Mr. Warington called attention to M. Buchet's results (*C. & D.* xl. 741—where the quantities are per 10,000, not per cent.) The use of an excess of ammonia by M. Buchet, he said, was an excellent device for dissolving the sulphate of lead otherwise insoluble. Reference was also made to Dr. Smith's process (conversion of the lead into chromate and weighing) upon which the Woolwich cases were decided, and Mr. Warington showed that this was not at all reliable, nor is the ordinary English colorimetric method, for (as was demonstrated to the meeting) when a milligramme of lead in water, in citric acid solution, and in tartaric acid solution was treated with sulphureted hydrogen solution, the water was very slightly colored, the tartaric solution was darker, and the citric acid darkest of all. Since, therefore, a standard lead solution in water only is unfit for comparative purposes, all comparisons by the colorimetric method should be made with lead dissolved in solution of lead-free acids. The precipitation of the sulphide is a hindrance to colorimetric observation, but Mr. Warington prevents the precipitation by the addition of glycerine, which he thinks has the effect of keeping the lead as sulphydrate. The only difficulty is that of getting a glycerine which will not give a yellow precipitate (tin or lead, Mr. Warington was not sure which) with sulphureted hydrogen. The objection to the use of the latter reagent is that the colors produced are so variable and misleading. With minute quantities we get a gray, then purple, bronze, and smoky brown. For quantities of lead above 20 parts per million only.

A more delicate and sure thing is to convert the acid into the corresponding ammonium salt, as in the following procedure:

Forty grammes of the tartaric or citric acid are dissolved in a little water, treated with excess of pure ammonia, and brought to 120 c. c. Fifty cubic centimeters of this solution, or a smaller quantity diluted to 50 c. c., are treated with 1 drop of ammonium sulphide in a Nesslerizing cylinder, and the clear brown color matched by an exactly similar mixture of pure tartaric or citric acid with ammonia and a measured quantity of the lead solution.

This method is extremely convenient, and is capable of estimating 1 part of lead per million of acid. In acids containing copper, or a distinct amount of iron, a preliminary treatment with potassium cyanide is resorted to.

Mr. Warington then called attention to the following tabulation of results from the examination of commercial samples of acids, but his remarks were cut short by the chairman, so that there is no explanation as to where the samples were obtained:

PERCENTAGES OF LEAD.

CITRIC ACID.

Makers		
English Makers.	0·0240	0·0105
	0·0195	0·0096
	0·0141	0·0066
	0·0059	0 0018
French and German.	0·0024	0·0006
United States.	0·0068	0·0030

TARTARIC ACID.

Makers			
English Makers.	0·0190	0·0110	
	0·0087	0·0047	
	0 0063	0·0033	
French Makers.	0·0190	0·0086	
	0·0033	0 0013	
	0·0008		
German Makers.	0·0087	0·0050	
	0·0084	0·0043	
	0·0035	0·0020	
	0·0029		
Unknown.	0·0113	0·0036	0·0032

It was shown that large crystals always contain less lead than the small, but why it could not be explained. After pointing out the errors of the Chamber of Commerce standard, Mr. Warington suggested that 5 parts of lead per million should be fixed as the standard of purity.

STARCH.

IN an article in the *Apothecary* on the "Starches of Root Drugs," E. S. Bastin insists upon the importance of a thorough knowledge of the different varieties of starch to pharmacists. While the kinds commonly employed as adulterants are generally well known, those naturally occurring in crude vegetable drugs are not at all familiar, and are frequently quite unknown. With the view of ascertaining the extent to which such knowledge would be of value, the author has carefully examined a large number of roots, and the results of his researches are embodied in the above-mentioned paper on the subject. The following concise statement of some modern views concerning the nature and occurrence of starch, by which Bastin introduces the subject, should prove of interest to pharmacists and students.

Starch is by far the most abundant and universally distributed of non-proteid reserve food materials found in plants, and it always exists in the form of corpuscles or granules. These appear to be composed of two substances: granulose, which constitutes by far the larger part of the grain (90 to 95 per cent. of its weight), and a skeleton composed of farinose or starch cellulose. It is only the former of these that stains blue with iodine solution. When all the granulose has been dissolved out by maceration in saliva, kept at a temperature of 98° F., the skeleton of farinose that remains stains only a brownish color with iodine. It is to be remarked that Krabbe denies that starch grains are composed of these two different substances, but regards the so-called farinose skeleton as a product of subsequent chemical change. But the weight of scientific opinion is in favor of the former view.

In structure the starch grain is not of equal density throughout. Every starch grain has a hilum or nuclear portion around which the rest of the grain has been deposited in layers, and the hilum and layers next to it are less dense than those farther exterior. The hilum may be located centrally in the grain, which then usually has a rounded form, or it may be located to one side of the center, in which case the form is apt to be elongated. Moreover, different layers of the grain usually contain different proportions of water, for

which reason there is often the appearance of concentric or eccentric lines or curves about the nucleus. These are very conspicuous in some starches, for example in that of the potato, but difficultly visible on many. In the latter case they are rendered distinct only by application of reagents that cause the grains to swell. On many others, perhaps the majority, concentric markings are not demonstrable at all.

Starch grains, in nearly all cases, if not actually in all, are formed by the agency of proteid bodies, either chloroplasts or amyloplasts. Those formed in chloroplasts under the action of sunlight are gradually dissolved and transferred as glucose or other soluble carbohydrate to some other part of the plant, where it is either employed in the processes of growth or else is stored again, usually in the form of starch, for future use. It is this, the reserve starch, which forms the conspicuous grains that are the subject of the present study. These are formed by amyloplasts, partly, at least, at the expense of the amyloplast itself, and partly, according to the investigations of Herr A. Meyer and M. E. Laurent, not only from glucose and cane sugar, but out of various other carbohydrates or bodies related to them, such, for example, as mannite. Strasburger holds, and apparently with good reason, that in rare instances starch is formed from the general protoplasm of the cell, and not solely from amyloplasts, and some have maintained that it is occasionally formed by mere crystallization in the cell, without the aid of any proteid whatsoever; but this certainly remains to be demonstrated.

Next to starch, perhaps the most common non-proteid reserve food material is fixed oil, and many seeds contain this to the exclusion of starch. There is the best of reason for believing, however, that fixed oil is formed from starch; for in all the cases of oily seeds or fruits that have been investigated, it has been found that in the unripe state the seed or fruit contains abundance of starch with little or no oil, and that as ripening progresses the starch is replaced by oil.

There are some plants, however, notably many composites, in which another carbohydrate, inulin, takes the place of starch from the first as a reserve food material. For this reason we look in vain for starch in the cells of inula, taraxacum, lappa, etc. From the whole group of fungi, also, starch is absent, being replaced functionally by some other carbohydrate. This seems to be connected with the fact that none of the fungi contain chlorophyl, and hence they are unable, like green plants, to utilize carbon dioxide as food.

As to whether starch grains are to be regarded as crystalline or colloid bodies, there is a difference of opinion among high scientific authorities. Schimper and Arthur Meyer regard them as sphere crystals, but Strasburger controverts this view and holds that the layers of the starch grain are formed not by crystalline deposit, but by the conversion of successive layers of proteid matter. The weight of scientific opinion is with Strasburger.

There are the best of reasons for believing that the polarization effects produced by starch grains are not due to crystalline structure, but to stress or strain, of the same nature as the polarization of glass when it is subject to strain. The polarizing effects are precisely such as would be produced in any transparent solid composed of layers, the inner ones of which were kept in a state of stress by the compression exerted by the outer ones. Moreover, when by use of a swelling reagent, such as caustic potash solution, the outer layers are made to expand by the imbibition of water, the polarization effects immediately disappear. Were the solid particles of a crystal thus forced apart by water, each particle would still exhibit polarization phenomena.

The tissues which most commonly contain starch, or which contain it in largest quantity, are those of the parenchymatous series, though it sometimes occurs in the latex of laticiferous tissues, and even in ducts and tracheids. In the stems of dicotyledons it occurs chiefly in the parenchyma of the middle and inner bark, in the medullary ray cells, and in the cells of the pith. In the roots of these plants it has a similar distribution, being for the most part confined to the middle and inner bark, and the medullary rays, pith not being present in these organs. In succulent stems and roots, of course, it also commonly occurs in the xylem tissues of the fibro-vascular bundles.

THE EXAMINATION OF SOAP.

By M. E. DEISS.

THE results of a large number of experiments have led the author to the conclusion that soap can be easily and accurately analyzed by means of volumetric methods. Olive oil soap, for example, is examined in the following way: ten grms. of soap are dissolved in 100 cbc of strong alcohol on the water bath, the solution immediately saturated with carbonic acid, in order to take up the free alkali, and the insoluble sodium carbonate filtered off and washed with hot alcohol. The alcoholic solution, which contains the combined alkali and the fatty acids, is diluted with a little water, a few drops of methyl orange added, and then titrated with normal hydrochloric acid. The combined alkali is thus found, and its amount obtained as sodium oxide (Na_2O) by multiplying the number of cbc's used by 0·031, while the fatty acids present in the ten grms. of soap are given by multiplying by 0·280. This number, 0·280, is the saponification equivalent of the olive oil used in the soap industry, and has been determined by a large number of experiments.

To determine the free alkali, the residue of sodium carbonate is dissolved in hot water, and titrated with decinormal acid, in the presence of methyl orange. The amount present in the ten grms. taken is found by multiplying the cbcs. of acid used by 0·0053. By means of this method other additions which are insoluble in alcohol, such as talc, heavy spar, etc., can also be detected.

When a soap is to be examined which has been made from a mixture of oils, the saponification equivalent to the acids contained in them must first be determined. This can be done by dissolving the dried and washed acids liberated from a solution of 9 grms. of soap in 30 cbc. of alcohol and titrating with decinormal acid in the presence of phenolphthalein. The number found as the saponification equivalent is then employed instead of 0·280.—*Rev. Internat. des Falsificat.*

RECOVERY OF SILVER RESIDUES.

THE residues are converted into silver chloride reduced with iron and dilute hydrochloric acid and washed until the chlorine reaction disappears. The silver, containing a little iron, is dissolved in pure nitric acid, the smaller portion is precipitated with boiling soda lye, and the precipitate is washed until a part of the filtrate leaves no residue. The larger portion is evaporated to dryness and then melted until the mass flows quietly. The melt is dissolved in water, filtered from the ferric oxide and slightly concentrated. Any nitrite formed is converted into nitrate by the addition of a small quantity of nitric acid. If the solution is colored yellow in consequence of the presence of a small quantity of ferric nitrate, the silver oxide mixed with iron oxide, obtained by the treatment of the smaller part of the silver solution, is added, and the whole is boiled until both are transformed into silver nitrate and ferric oxide, *i. e.*, until a filtered and diluted portion gives with potassium ferrocyanide a pure white flocculent precipitate or turbidity. The whole is evaporated to dryness, taken up in water, and again evaporated to dryness.—*R. Dietel, Pharm. Zeitung.*

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